ELEMENTS OF BOTANY

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PREFACE.

The present text-book is, for the most part, an expansion of the manuscript notes which have for some years formed the basis of the botany-teaching in the Boston English High School. These notes were drawn up by Mr. Samuel F. Tower and the author, for the purpose of establishing what seemed to them a suitable half-year course in botany for pupils of the entering class in that school.

It will be found that this book differs from most American text-books designed for use in secondary schools, in endeavoring to combine in one volume the simplest possible directions for laboratory work with an outline of vegetable anatomy and physiology, and a brief statement of the principles of botanical classification. An account of the functions of the tissues or organs described usually follows as closely as may be the account of the parts in question. The attempt is made to discuss plants dynamically rather than statically, to view them as contestants in the struggle for existence, and to consider some of the conditions of success and failure in the vegetable world. While the determination of species by means of an artifical key is illustrated, preparation for this process is by no means the main object or even a principal end which the author has had in view. The tendency of botany-teaching seems to be more and more away from the old ideal of enabling one's pupils to run down a species as expeditiously as possible, and teaching them how to preserve a properly ticketed memento of the chase.

The illustrations drawn from nature, or redrawn expressly for this book, are mostly by Orville P. Williams or Francis M. West, recent graduates of the English High School. The woodcut of *Monotropa* is from a photograph kindly loaned for the purpose by its maker, Rev. R. S. Morison. Large numbers of illustrations have been reproduced from the following works, which are named in about the order of the extent to which they have been drawn upon:

Le Maout and Decaisne's *Traité Général de Botanique.*
Thomé's *Structural and Physiological Botany.*
Tschirch's *Angewandte Pflanzenanatomie.*
Strasburger, Noll, Schenk, and Schimper's *Lehrbuch der Botanik.*
Kerner's *Pflanzenleben.*
Figuier's *Vegetable World.*
Behrens's *Text-book of General Botany.*
Sachs's *Text-book of Botany.*

The author is to a less extent indebted for cuts to the works of Brown, Carpenter, Darwin, Lindley, Lubbock, Potonie, Strasburger, Hartig, Host, Kny, Detmer, Martius, Baillon, and others.

For most of the subject-matter of this book — though not for the order and mode of treatment — the writer is of course indebted to a multitude of sources, only a very few of which are indicated in the subjoined bibliography. Personal assistance has been freely rendered him by Prof. George L. Goodale, Dr. Benjamin L. Robinson, Curator of the Gray Herbarium, and Mr. A. B. Seymour of the Cryptogamic Herbarium of Harvard University. Prof. George J. Pierce of Indiana State University has given valuable aid in regard to some physiological questions. Prof. William F. Ganong of Smith College has done so much for the book that if it should prove useful its value will be largely due to his suggestive criticisms. Thanks are due for the careful proof-reading of

Prof. George G. Groff of Bucknell University, Lewisburg, Pa., Miss Anna A. Schryver of the Michigan State Normal School, Ypsilanti, Mr. Hermann von Schrenk of the St. Louis Manual Training School, and Mr. Marcus L. Glazer of the St. Cloud., Minn., High School.

Part II consists of a very brief key to some of the commoner orders of Phanerogams and descriptions of the characteristics of these orders with a few genera and species under each. The key is adapted (by permission) from the one in use in the elementary course in botany in Harvard University, and the descriptions were compiled by the author from the most accessible recent floras of the northern United States east of the hundredth meridian. The attempt has been made to simplify the language and condense the descriptions, but not so much as to make them hopelessly bald and unreadable. The plants chosen to constitute this greatly abbreviated flora are those which bloom during some part of the latter half of the ordinary school year, and which have a rather wide territorial range. Enough forms have been described to afford ample drill in the determination of species. Gray's *Manual of Botany* or *Field, Forest and Garden Botany* will of course be employed by the student who wishes to become familiar with the flora of the region here touched upon. Those species which occur in the north-eastern United States only as cultivated plants are so designated, but it has not seemed best to take the necessary space to assign precise ranges or habitats to the native or introduced plants here described.

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ELEMENTS OF BOTANY.

INTRODUCTORY.

"Botany is the science which endeavors to answer every reasonable question about plants."[1]

The plant is a living being, provided generally with many parts, called *organs*, which it uses for taking in nourishment, for breathing, for protection against its enemies, and for reproducing itself and so keeping up the numbers of its own kind. The study of the individual plant therefore embraces a variety of topics, and the examination of its relation to others introduces many more subjects.

Morphology, or the science of form, structure, and so on, deals with the plant without much regard to its character as a living thing. Under this head are studied the forms of plants and the various shapes or disguises which the same sort of organ may take in different kinds of plants, their gross structure, their microscopical structure, their classification, and the successive stages in the history of the germs from which all but a few of the very simplest plants are formed.

Geographical Distribution, or botanical geography, discusses the range of the various kinds of plants over the earth's surface. Another subdivision of botany, usually studied along with geology, describes the history of plant life on the earth from the appearance of the first plants until the present time.

[1] Professor George L. Goodale.

Vegetable Physiology treats of the plant in action, how it lives, breathes, feeds, grows, and produces others like itself.

Vegetable Ecology treats of the relations of the plant to the conditions under which it lives. Under this division of the science are studied the effects of soil, climate, and friendly or hostile animals and plants on the external form, the internal structure and the habits of plants.

Many of the topics suggested in this outline cannot well be studied in the high school. There is not usually time to take up botanical geography or to do much more than mention the important subject of *Economic Botany*, the study of the uses of plants to man. It ought, however, to be possible for the student to learn in his high school course a good deal about the simpler parts of morphology and of vegetable physiology. One does not become a botanist — not even much of an amateur in the subject — by reading books about botany. It is necessary to study plants themselves, to take them to pieces and make out the connection of their parts, to examine with the microscope small portions of the exterior surface and thin slices of all the variously built materials or *tissues* of which the plant consists. All this can be done with living specimens or with those taken from dead parts of plants that have been preserved in any suitable way, as by drying or by placing in alcohol or other fluids which prevent decay. Living plants must be studied in order to ascertain what kinds of food they take, what kinds of waste substances they excrete, how and where their growth takes place and what circumstances favor it, how they move, and indeed to get as complete an idea as possible of what has been called the behavior of plants.

Since the most familiar and most interesting plants spring from seeds, the beginner in botany can hardly do better than to examine at the outset the structure of a few familiar seeds,

then sprout them and watch the growth of the seedlings which spring from them. Afterwards he may study in a few typical examples the organs, structure, and functions of flowering plants, trace their life-history, and so, step by step, follow the process by which a new crop of seeds at last results from the growth and development of such a seed as that with which he began.

Meantime it will throw light on the mode of growth of flowering plants to compare them with a few very simple flowerless plants.

After the whole round of vegetable life has been outlined from seed to seed, the student may learn a little about the never-ceasing struggle against unfavorable climates, poor soils, and the direct attacks of living enemies, — in short, the many kinds of adverse influences, such as all plants must meet and overcome in order to maintain their footing on the earth.

Finally, some idea may be gained of the relationships of plants to each other, or *Systematic Botany*.

CHAPTER I.

The Seed and its Germination.

1. *Germination of Squash-Seed.* — Soak some squash-seeds in tepid water for twelve hours or more. Plant these about an inch deep in damp sand or pine sawdust in a wooden box which has had holes enough bored through the bottom so that it will not hold water. Put the box in a warm place (not at any time over 70° or 80° Fahrenheit), and cover it loosely with a board or a pane of glass. Keep the sand or sawdust moist, but not wet, and the seeds will germinate. As soon as any of the seeds, on being dug up, are found to have burst open, sketch one in this condition, noting the manner in which the outer seed-coat is split, and continue to make sketches at intervals of two days, until at least eight stages in the growth of the plantlet have been noted.[1]

Observe particularly how the sand is pushed aside by the rise of the young seedlings, and make one sketch to show what part of the plant first appears above the surface. Suggest some reason for the manner in which the sand is penetrated by the rising stem.

The student need not feel that he is expected to make finished drawings to record what he sees, but some kind of sketch, if only the merest outline, is indispensable. Practice and the study of the illustrations hereafter given will soon give some facility even to those who have had little or no instruction in drawing. Consult here Figs. 7 and 58.

2. *Examination of the Squash-Seed.* — Make a sketch of the dry seed, natural size. Note the little scar at the pointed end of the seed where the latter was attached to its place of growth in the squash. Label this *hilum.*

Describe the color and texture of the outer coating of the seed. With a scalpel or a very sharp knife cut across near the middle a seed that has been soaked in water for 24 hours. Squeeze one of the portions, held edgewise between the thumb and finger, in such a way as to separate slightly the halves into which the contents of the seed is naturally divided. Examine with the magnifying glass the section thus treated,

[1] The class is not to wait for the completion of this work (which may, if desirable, be done by each pupil at home), but is to proceed at once with the examination of the squash-seed and of other seeds, as directed in the following sections, and to set some beans to sprouting, so that they may be studied along with the germinating squashes.

make a sketch of it and label the shell or covering of the seed and the kernel within this.

Taking another soaked seed, chip away the white outer shell, called the *testa*, and observe the thin, greenish inner skin, the *tegmen*, with which the kernel of the seed is closely covered.

Strip this off and sketch the uncovered kernel, or *embryo*. Note that at one end it tapers to a point. This pointed portion, known as the *caulicle*, will develop after the seed sprouts into the stem of the plantlet, like that shown at *hc* in Fig. 1.

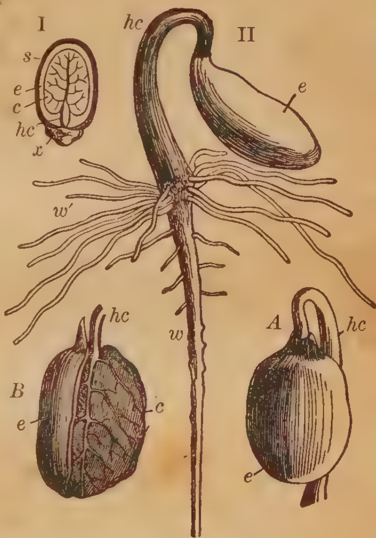


FIG. 1. — The Castor Bean and its Germination. I, longitudinal section of the ripe seed; II, germinating seed; *hc*, caulicle; *c*, cotyledon; *e*, nourishment stored around the cotyledons; *s*, testa; *x*, thickened knot at end of seed; *w*, primary root; *w′*, secondary roots.

Split the halves of the kernel entirely apart from each other, noticing that they are only attached for a very little way next to the caulicle, and observe the thickness of the halves and the slight unevenness of the inner surfaces. These halves are called seed-leaves or *cotyledons*.

Have ready some seeds which have been soaked for 24 hours and then left in a loosely covered jar on damp blotting-paper at a temperature of 70° or over until they have begun to sprout.

Split one of these seeds apart, separating the cotyledons, and observe, at the junction of these, two very slender pointed objects, the rudimentary leaves of the *plumule* or first bud.

3. *Examination of the Bean.* — Study the seed, both dry and after 12 hours' soaking, in the same general way in which the squash-seed has just been examined.[1]

[1] The larger the variety of bean chosen, the easier it will be to see and sketch the several parts. The large red kidney bean or the horticultural bean will do well for this examination.

Notice the presence of a distinct plumule, consisting of a pair of rudimentary leaves between the cotyledons, just where they are joined to the top of the caulicle.

Make a sketch of these leaves as they lie in place on one of the cotyledons, after the bean has been split open.

Note the cavity in each cotyledon caused by the pressure of the plumule. Place that cotyledon from which the sketch was made on the stage of the compound microscope under the lowest-power objective which the microscope has (say 2-inch), with light thrown on the object from above, and sketch the plumule as thus shown.[1]

4. *Examination of the Pea.* — There are no very important points of difference between the bean and pea, so far as the structure of the seed is concerned, but the student should rapidly dissect a few soaked peas to get an idea of the appearance of the parts, since he is to study the germination of peas in some detail.

Make only one sketch, that of the caulicle as seen in position after the removal of the seed-coats.[2]

5. *Germination of the Bean and the Pea.* — Soak some beans as directed in § 3, plant them, and sketch as there directed.

Follow the same directions with some peas.[3]

6. *Germination of the Horse-Chestnut.* — Plant some seeds of the horse-chestnut or the buckeye, study their mode of germination and make out the nature and peculiar modifications of the parts.

Consult Gray's *Botanical Text-Book*, vol. I, pp. 19, 20.

7. *Conditions Requisite for Germination.* — When we try to enumerate the external conditions which can affect germination, we find that the principal ones are light, heat, moisture, and presence of air. A few simple experiments will show what influence these conditions exert.

8. ***Experiment 1.***[4] (a) *Does Light assist Germination?* (b) *Does Light retard Germination?* — Put a piece of blotting-paper in the bottom

[1] The teacher should at this point give a short illustrated talk to explain in a general way the construction and use of the compound microscope. See Appendix A.

[2] The teacher will find excellent sketches of most of the germinating seeds described in the present chapter in Miss Newell's *Outlines of Lessons in Botany*, Part I, and in Gray's *Lessons in Botany*.

[3] The pupil may economize space by planting the new seeds in boxes from which part of the earlier-planted seeds have been dug up for use in sketching, etc.

[4] This may readily be made a home experiment.

of a tumbler, and add just water enough thoroughly to soak the paper. Pour out any excess. Place on the paper a few seeds (peas, barley, wheat, oats) that have been soaked for 24 hours; cover to prevent evaporation and put the tumbler in a light place.

Put the same number of other seeds of the same sort in a cup or box which will not admit light.

Add a few drops of water from time to time, if the seeds or paper seem to be drying. Place the cup and tumbler side by side, so that they will have the same temperature, and watch for results.

Tabulate your results something like this:

No. of seeds sprouted in	24 hrs.	48 hrs.	72 hrs.	96 hrs.
In dark,	——	——	——	——
In light,	——	——	——	——

N. B. — Take special pains to have the conditions of moisture and heat the same in the cup and in the tumbler.

9. ***Experiment 2.*** *Relation of Temperature to Germination.* — Arrange several vessels as in Exp. 1. Put in each vessel the same number of soaked peas.[1] Stand the vessels with their contents in places where they will be exposed to different, but fairly constant, temperatures and observe the several temperatures carefully with a thermometer. The following series is merely suggested, — other values may be found more convenient. Note the rate of germination in each place and record in tabular form as follows:

No. of seeds sprouted in	24 hrs.	48 hrs.	72 hrs.	96 hrs.	etc.
At 32 degrees,	——	——	——	——	——
At 50 degrees,	——	——	——	——	——
At 70 degrees,	——	——	——	——	——
At 90 degrees,[2]	——	——	——	——	——

10. ***Experiment 3.***[3] *Relation of Water to Germination.* — Arrange seeds in several vessels as follows:

In the first put blotting-paper that is barely moistened: on this put some dry seeds.

[1] If peas are used one year, Indian corn another year, squash-seeds another, and so on, a series of data will be obtained which may be quoted to the class after the experiment as above given has been completed.

[2] Here and elsewhere throughout the book temperatures are expressed in Fahrenheit degrees, since with us, unfortunately, the Centigrade scale is not the familiar one, outside of physical and chemical laboratories.

[3] May be a home experiment.

In the second put blotting-paper that has been barely moistened; on this put seeds that have been soaked for 24 hours.

In the third put water enough thoroughly to soak the paper: use soaked seeds.

In the fourth put water enough to half cover the seeds.

Place the vessels where they will have same temperature and note the time of germination.

Tabulate your results as in the previous experiments.

11. ***Experiment 4.**** [1] *Will Seeds germinate without Air?*— Place some soaked seeds on blotting-paper in the bottom of a bottle; close tightly with a perforated rubber stopper through which has been passed a long glass tube bent once at right angles as shown in Fig. 2.

FIG. 2.—Soaked Peas in Stoppered Bottle, ready for Exhaustion of Air.

Exhaust the air from the bottle by attaching the tube to an air-pump or an aspirator, and after considerable pumping and while the exhaustion is going on, seal the whole air-tight by heating the tube near the bend with a Bunsen burner or alcohol lamp flame until it can be drawn out to a thread.

The stopper will be more certain to prove air-tight if it has been well moistened with glycerine or vaseline before being inserted in the bottle.

Place other seeds of the same kind in another bottle and stopper tightly.

Place other seeds of the same kind in a third bottle; stopper loosely.

Place the three bottles side by side, so that they will have the same conditions of light and heat. Watch for results, and tabulate as in previous experiments.

Most seeds will not germinate under water, but those of the sunflower will do so, and therefore Exp. 4 may be varied in the following manner:

[1] Experiments marked thus * are to be performed by the teacher in the laboratory or class-room.

Remove the shells carefully from a considerable number of sunflower seeds.[1] Try to germinate one lot of these in water which has been boiled, to remove the air, and then cooled and poured into a bottle which it fills up to the (tightly fitting) rubber stopper. In this bottle then there will be only seeds and water, no air-space. Try to germinate another lot of seeds in a bottle half filled with ordinary water.

12. *Germination involves Chemical Changes.* — If a thermometer is inserted into a jar of sprouting seeds, for instance peas, in a room at the ordinary temperature, the peas will be found to be warmer than the surrounding air. This rise of temperature is at least partly due to the absorption from the air of that substance in it which supports the life of animals and maintains the burning of fires, namely *oxygen.*

The union of oxygen with substances with which it can combine, that is with those which will burn, is called *oxidation.* This kind of chemical change is universal in plants and animals while they are in an active condition, and the energy which they manifest in their growth and movements is as directly the result of the oxidation going on inside them as the energy of a steam-engine is the result of the burning of coal or other fuel under its boiler. In the sprouting seed much of the energy produced by the action of oxygen upon oxidizable portions of its contents is expended in producing growth, but some of this energy is wasted by being transformed into heat which escapes into the surrounding soil. It is this escaping heat which is detected by a thermometer thrust into a quantity of germinating seeds.

13. ***Experiment 5.**** *Effect of Germinating Seeds upon the Surrounding Air.* — When Exp. 4 has been finished, insert into the air above the peas in the second bottle a lighted pine splinter, and note the effect upon its flame.

Besides the proofs of chemical changes in germinating seeds just described, there are other kinds of evidence to the same effect.

[1] These are really fruits, but the distinction is not an important one at this point.

Malt, which is merely sprouted barley with its germination permanently stopped at the desired point by the application of heat, tastes much sweeter than the unsprouted grain, and can be shown by chemical tests to have suffered a variety of changes.

Germinating kernels of corn undergo great alterations in their structure (see Fig. 12).

14. *The Embryo and its Development.* — The miniature plant, as it exists ready-formed in the seed, is called the *embryo.* In the seeds so far examined the entire contents of the seed-coats consist of the embryo, but this is not the case with the great majority of seeds.

As soon as the young plants of squash, bean, and pea have reached a height of three or four inches above the ground it is easy to recognize important differences in the way in which they set out in life.

The cotyledons of the squash increase greatly in surface, acquire a green color and a generally leaf-like appearance, and, in fact, do the work of ordinary leaves. In such a case as this the appropriateness of the name seed-leaf is evident enough, — one recognizes at sight the fact that the cotyledons are actually the plant's first leaves. In the bean the leaf-like nature of the cotyledons is not so clear. They rise out of the ground like the squash cotyledons, but then gradually shrivel away, though they may first turn green and somewhat leaf-like for a time.

In the pea (as in the acorn, the horse-chestnut, and many other seeds) we have quite another plan, the underground type of germination. Here the thick cotyledons no longer rise above ground at all, because they are so gorged with nourishment that they could never become leaves; but the young stem pushes rapidly up from the surface of the soil.

The development of the plumule seems to depend somewhat on that of the cotyledons. The squash-seed has cotyledons

which are not too thick to become useful leaves, and so the plant is in no special haste to get ready any other leaves. The plumule, therefore, cannot be found with the magnifying glass in the unsprouted seed, and is almost microscopic in size at the time when the caulicle begins to show outside of the seed-coats.

In the bean and pea, on the other hand, since the cotyledons cannot serve as leaves, the later leaves must be pushed forward rapidly. In the bean the first pair are already well formed in the seed. In the pea they cannot be clearly made out, since the young plant forms several scales on its stem before it produces any full-sized leaves, and the embryo contains only caulicle, cotyledons, and a sort of knobbed plumule, well developed in point of size, representing the lower scaly part of the stem.

CHAPTER II.

The Parts of the Seedling;—its Development.

15. *Root, Stem, and Leaf.*—By the time the seedling is well out of ground it, in most cases, possesses the three kinds of *vegetative organs*, or parts essential to growth, of ordinary flowering plants, the root, stem, and leaf. All of these organs may multiply and increase in size as the plant grows older, and their mature structure will be studied in later chapters, but some facts concerning them can best be learned by watching their growth from the outset.

16. *The Young Root.*—Roots growing in sand or ordinary soil cling to its particles so tenaciously that they cannot easily be studied, and those grown in water have not quite the same form as soil roots. Roots grown in damp air are best adapted for careful study.

Experiment 6. *In what Portions of the Root does its Increase in Length take Place?*—Sprout some peas on moist blotting-paper in a loosely covered tumbler. When the roots are one and a half inches or more long, mark them along the whole length with little dots made with a very small camel's-hair brush or a bristle dipped in water-proof India ink.

Transfer the plants to moist blotting-paper under a bell glass or a battery jar and examine the roots at the end of twenty-four hours to see along what portions their length has increased; continue observations on them for several days.

17. *Root-Hairs.*—Barley, oats, wheat, or red clover seed soaked and then sprouted on moist blotting-paper afford convenient material for studying *root-hairs*. The seeds may be kept covered with a watch-glass or a clock-glass while sprouting. A few of the red clover seeds should also be sprouted in a deep cell on a microscope-slide. Examine those parts of the root which have these appendages, first with the magnify-

ing glass, then as opaque objects in a cell under a low power of the miscroscope; finally cut off a very small portion of the root with its hairs and examine in water with a power of 150 to 200 diameters.[1]

Make several sketches of the root-hairs and compare with Figs. 5 and 19. Notice that they do not cover all portions

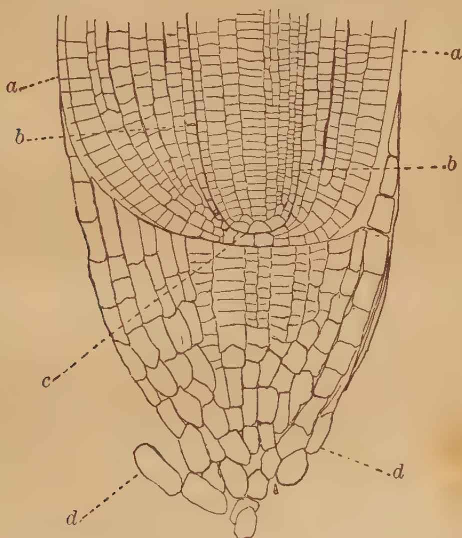


FIG. 3.—Lengthwise Section through Tip of a Root of Barley. (Much magnified.) *a*, thick outer wall of epidermis; *b* (portion bounded by the heavy line), the central cylinder of the root; *c*, the growing-point, from which the root-cap is produced (in this and similar plants) and from which growth in length proceeds; *d*, loose cells of the root-cap.

of the rootlets. Where are they most abundant? Observe that each hair is a slender closed tube, with very thin walls made of the tough material called *cellulose.*

The root-hairs in plants growing under ordinary conditions

[1] Great care is needed to prevent the root-hairs from becoming distorted by pressure, and they shrivel up in dry air almost at once.

are surrounded by the moist soil and wrap themselves around microscopical particles of earth. Thus they are able rapidly to absorb through their thin walls the soil-water, with whatever mineral substances it has dissolved in it.

18. *The Root-Cap.*—The tips of young roots and rootlets,

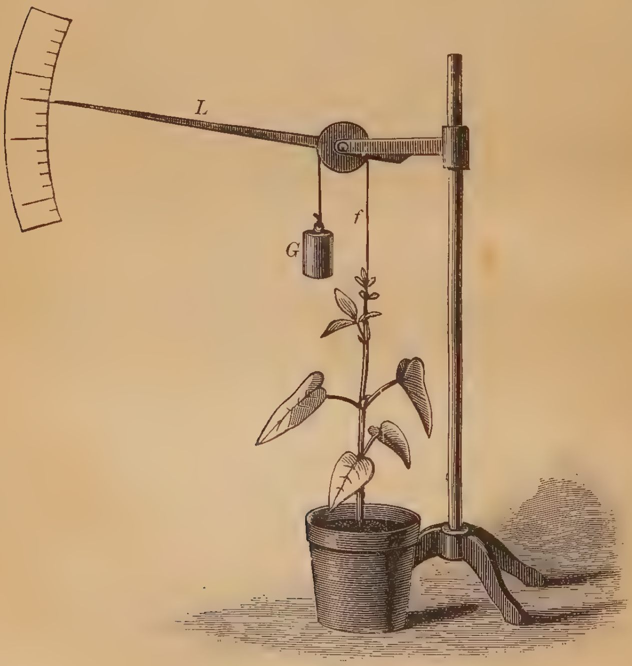


FIG. 4.—Apparatus for Measurement of Growth.

as they bore their way through the soil, are protected from injury by a coating of loose cells, called the *root-cap*, shown at *d* in Fig. 3. It will be seen from this figure that no root-hairs proceed from the root-cap, and indeed there is very little absorption of water going on in this place. In the so-

called water-hyacinth[1] that which occupies the place of an ordinary root-cap is a long sheath, which may be pulled off entire; its large size is possibly due to the fact that it is not worn away by friction against the soil.

19. *The Young Stem.* — The caulicle, or portion of the stem which lies below the cotyledons, is the earliest-formed portion of the stem. Sometimes this lengthens but little; often, however, as the student knows from his own observations, the caulicle lengthens enough to raise the cotyledons well above ground, as in Fig. 5.

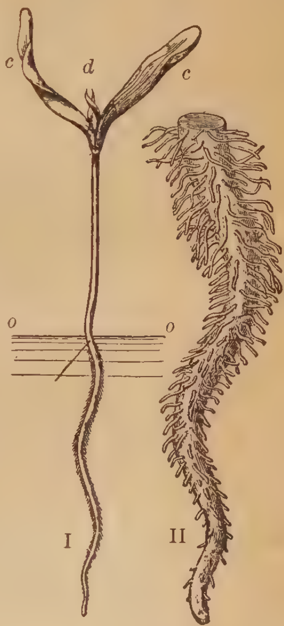


FIG. 5. — I, a seedling maple, natural size; *c*, cotyledons; *d*, plumule; *o*, level of the ground; II, part of root of the same, magnified six times, showing root-hairs.

The later portions of the stem are considered to be divided into successive *nodes*, places at which a leaf (or a scale which represents a leaf) appears, and *internodes*, portions between the leaves.

The student should watch the growth of a seedling bean or pea and ascertain by actual measurements whether the internodes lengthen after they have once been formed, and if so, for how long a time the increase continues.

The rate of growth may readily be measured by means of a simple piece of apparatus, shown in Fig. 4. This consists of a pointer *L* supported by an upright stand, moving over a graduated arc, and with a grooved

[1] A plant somewhat common in greenhouses, allied to the ordinary pickerel weed of the streams and ponds of New England.

pulley attached to its axis. Over this pulley a cord *f* passes. One end of the cord is fastened to the tip of the stem of the plant of which the growth is to be measured and the other end has a weight *G* attached to it. As the plant grows the pointer *L* descends on the scale. The actual rate of growth is obtained by multiplying the distance which the pointer travels over the arc by the fraction which expresses the ratio of the half-diameter of the pulley to the length of *L* from arc to pivot.

Contrast the mode of growth of the root and the stem and try to give a reason for that of the root.

20. *The First Leaves.*—The cotyledons are, as already explained, the first leaves which the seedling possesses,—even if a plumule is found well developed in the seed, it was formed after the cotyledons. In those plants which have so much nourishment stored in the cotyledons as to render these unfit ever to become useful leaves, there is little or nothing in the color, shape, or general appearance of the cotyledon to make one think it really a leaf, and it is only by studying many cases that the botanist is entitled to class all cotyledons as leaves in their nature, even if they are quite unable to do the work of leaves. The study of the various forms which the parts or organs of a plant may assume is called *morphology;* it traces the relationship of parts which are really akin to each other, though dissimilar in appearance and often in function. In seeds which have *endosperm*, or nourishment stored outside of the embryo, the cotyledons usually become green and leaf-like, as they do, for example, in the four-o'-clock and the morning-glory, but in the seeds of the grains (which contain endosperm) a large portion of the single cotyledon remains throughout as a thickish mass buried in the seed. In a few cases, as in the pea, there are scales instead of true leaves formed on the first nodes above the cotyledons, and it is only at about the third node above that leaves of the ordinary kind appear. In the bean and some other plants which in general bear one leaf at a node along the stem, there is a pair produced at the first node above

the cotyledons, and the leaves of this pair differ in shape from those which arise from the succeeding portions of the stem.

21. *Classification of Plants by the Number of their Cotyledons.* — In the pine family the germinating seed often displays more than two cotyledons, as shown in Fig. 6; in the majority of common flowering plants the seed contains two cotyledons, while in the lilies, the rushes, the sedges, the grasses, and some other plants there is but one cotyledon. Upon these facts is based the division of most flowering plants into two great groups: the *dicotyledonous plants,* which have two seed-leaves, and the *monocotyledonous plants,* which have one seed-leaf. Other important differences constantly accompany the difference in number of cotyledons, as will be seen later.

FIG. 6. — Germinating Pine. *c*, cotyledons.

CHAPTER III.

Storage of Nourishment in the Seed.

22. *Nourishment in the Embryo.* — Squash-seeds are not much used for human food, though both these and melon-seeds are occasionally eaten in parts of Europe, but beans and peas are important articles of food. Whether the material accumulated in the cotyledons is an aid to the growth of the young plant may be learned from a simple experiment.

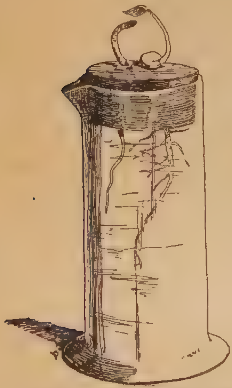


FIG. 7. — Germinating Peas, growing in Water, one deprived of its Cotyledons.

23. ***Experiment 7.**** *Are the Cotyledons of a Pea of any Use to the Seedling?*[1] — Sprout several peas on blotting-paper. When the plumules appear, carefully cut away the cotyledons from some of the seeds. Place on a perforated cork, as shown in Fig. 7, one or two seedlings from which the cotyledons have been cut, and as many which have not been mutilated, and allow the caulicles to extend into the water. Let them grow for some days, or even weeks, and note results.

24. ***Experiment 8.***[2] *Does the Amount of Material in the Seed have anything to do with the Rate of Growth of the Seedling?* — Germinate ten or more clover-seeds, and about the same number of peas, on moist blotting-paper under a bell jar. After they are well sprouted, transfer both kinds of seeds to fine cotton netting, stretched across wide-mouthed jars nearly full of water. The roots should dip into the water, but the seeds must not do so. Allow the plants to grow until the peas are from 4 to 6 inches high.

Some of the growth in each case depends on material

[1] The pea is used in a large number of the experiments here given, because it germinates at a comparatively low temperature, and the young seedlings are very hardy and thrive readily in the schoolroom.

[2] May be a home experiment.

gathered from the air and water, but most of it, during the very early life of the plant, is due to the reserve material stored in the seed.

Any one who has watched the slow growth of seedling grass plants and the very rapid growth of young corn plants can appreciate the effect of an abundant supply of food in the seed in securing a rapid start for the seedling. This particular illustration is a good one, since corn is itself a kind of grass.

25. *Storage of Nourishment outside of the Embryo.* — In very many cases the cotyledons contain little nutriment, but there is a supply of it stored in the seed beside or around them, Figs. 1 and 8.

26. *Examination of the Four-o'clock Seed; its Germination.* — Examine the external surface of a seed[1] of the four-o'clock, and try the hardness of the outer coat by cutting it with a knife. From seeds which have been soaked in water at least 24 hours peel off the coatings and sketch the kernel. Make a cross-section of one of the soaked seeds which has not been stripped of its coatings, and sketch the section as seen with the magnifying glass, to show the parts, especially the two cotyledons, lying in close contact and encircling the white starchy-looking *endosperm.*[2]

I. II.

FIG. 8. — Seeds with Endosperm, Longitudinal Sections.

I, asparagus (magnified).
II, poppy (magnified).

The name endosperm is applied to nourishment stored in parts of the seed other than the embryo. With a mounted needle pick out the little almost spherical mass of endosperm from inside the cotyledons of a seed which has been deprived of its coats, and sketch the embryo, noting how it is curved so as to inclose the endosperm almost completely.

Sketch the germinating seed and the young seedling at two or three stages of its growth to show the form and development of the cotyledons, and try to find out whether the endosperm disappears.

27. *Examination of the Kernel of Indian Corn; its Germination.* — Soak some grains of large yellow field-corn[3] for about three days.

[1] Strictly speaking a fruit.

[2] Buckwheat furnishes another excellent study in seeds with endosperm. Like that of the four-o'clock it is, strictly speaking, a fruit.

[3] The varieties with long flat kernels, raised in the Middle and Southern States under the name of "dent corn," are the best.

Sketch an unsoaked kernel, so as to show the grooved side, where the germ lies. Observe how this groove has become partially filled up in the soaked kernels.

Remove the thin tough skin from one of the latter, and notice its transparency. This skin — the bran of unsifted corn meal — does not exactly correspond to the testa and tegmen of ordinary seeds, since the kernel of corn, like all other grains (and like the seed of the four-o'clock), represents not merely the seed, but also the seed-vessel in which it was formed and grew as well as the outermost part of the flower (the *calyx*).

Cut sections of the soaked kernels, some transverse, some lengthwise and parallel to the flat surfaces, some lengthwise and at right angles to the flat surfaces. Stain with iodine solution.

Make a sketch of one section of each of the three kinds, and label the dirty white portion, of cheesy consistency, *embryo;* and the yellow portions, and those which are white and floury, *endosperm.*

Chip off the endosperm from one kernel so as to remove the embryo free from other parts.[1] Notice its form, somewhat triangular in outline, sometimes nearly the shape of a beechnut, in other specimens nearly like an almond.

Estimate what proportion of the entire bulk of the soaked kernel is embryo.

Split the embryo lengthwise so as to show the slender, somewhat conical plumule.[2]

Sprout a considerable number of kernels of corn in sand or pine sawdust, at a temperature of 70 or 80 degrees, and make several sketches to illustrate the growth of the plumule and the formation of roots; first a main root from the base of the caulicle, then others more slender from the same region, and later on still others from points higher up on the stem. The student may be able to make out what becomes of the large outer part of the embryo. This is really the single cotyledon of the corn. It does not rise above ground, but most of it remains in the buried grain, and acts as a digesting and absorbing organ through which the endosperm is transferred into the growing plant, as fast as it can be made liquid for that purpose.

[1] The embryo may be removed with great ease from kernels of rather mature green corn after twenty minutes' boiling on the cob, then picking the kernels off one by one with the point of a knife. They may be preserved indefinitely in alcohol.

[2] The teacher may well consult Figs. 66, 67, 68 in Gray's *Lessons in Botany*, revised ed.

Compare the kernel of corn and its germination with the oat, Fig. 9.

28. *Experiment 9.* *Of how much Use to the Corn Seedling is the Endosperm?* — Sprout kernels of corn on blotting-paper. When they get fairly started, cut away the endosperm carefully from several of the seeds. Suspend on mosquito netting over water in the same jar two or three seedlings which have lost their endosperm, and as many which have not been mutilated. Let them grow for some weeks, and note results.

29. *Starch.* — Most common seeds contain starch. Every one knows something about the appearance of ordinary commercial starch as used in the laundry, and as sold for food in packages of corn-starch. It is not always easy, however, to recognize at sight the presence of starch as it occurs in seeds, but it may be detected by a very simple chemical test, namely, the addition of a solution of iodine.[1]

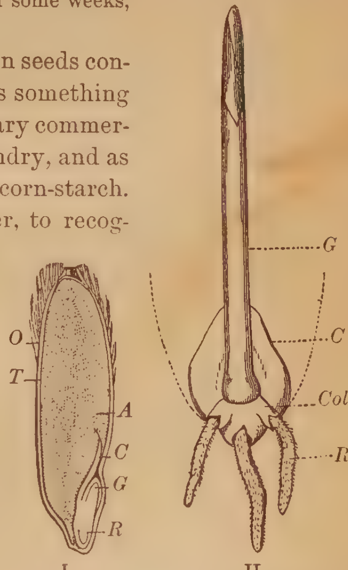


FIG. 9. — The Oat. I, Fruit, longitudinal section. *R*, caulicle; *G*, plumule; *C*, cotyledon; *A*, endosperm; *T*, testa; *O*, wall of ovary. II, Germination. *G*, plumule; *C*, cotyledon; *Col*, sheath of caulicle; *R*, root.

30. *Experiment 10.* *Test Seeds with Iodine for Starch.*[2] — Pulverize one or two seeds,[3] add two or three drops of boiling water to soften and swell the starch, and then add, drop by drop, the iodine solution. Only a little is necessary; sometimes the first drop is enough.

If starch is present, a blue color (sometimes almost black) will appear. If no color is obtained in this way, boil the pulverized seeds for a moment in a few drops of water, and try again.

[1] The tincture of iodine sold at the drug-stores will do, but the solution prepared as directed in Appendix B answers better. This may be made up in quantity, and issued to the pupil in drachm vials, to be taken home and used there, if the experimenting must be done outside of the laboratory or the schoolroom.

[2] May be a home experiment.

[3] With large seeds, like a nut, only part of one will be necessary.

Test in this manner wheat (in the shape of flour), oats (in oatmeal), barley, rice, buckwheat, flax, rye, sunflower, four-o'clock, morning-glory, beans, peanuts, Brazil-nuts, hazel-nuts, and any other seeds that you can get. Report your results in tabular form as follows:

Much Starch.	Little Starch.	No Starch.
Color, blackish or dark blue.	Color, pale blue or greenish.	Color, brown, orange, or yellowish.

31. *Microscopical Examination of Starch.* — Examine starch in water with a rather high power of the microscope (not less than 200 diameters). Pulp scraped from a potato, wheat flour, the finely powdered starch sold under the commercial name of "corn-starch" for cooking, oatmeal and buckwheat finely powdered in a mortar, will furnish five excellent examples of the shape and markings of starch-grains. Sketch all of the kinds examined, taking pains to bring out the markings.[1] Compare the sketches with Figs. 10 and 11.

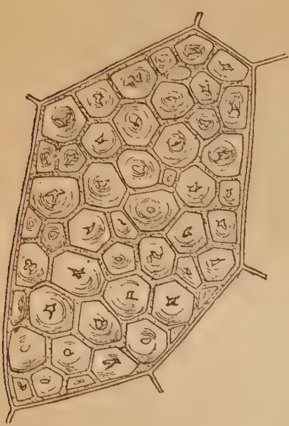


Fig. 10. — Starch-Grains stored in a Cell in a Grain of Indian Corn. (Greatly magnified.)

With a medicine-dropper or a very small pipette run in a very little iodine solution under one edge of the cover-glass, at the same time withdrawing a little water from the margin opposite by touching to it a bit of blotting-paper. Examine again and note the blue coloration of the starch-grains and the unstained or yellow appearance of other substances in the field. Cut very thin slices from beans, peas, or kernels of corn; mount in water, stain as above directed, and draw as seen under the microscope. Compare with Figs. 10 and 11.[2] Note the fact that the starch is not packed away

[1] The markings will be seen more distinctly if care is taken not to admit too much light to the object. Rotate the diaphragm beneath the stage of the microscope, or otherwise regulate the supply of light, until the opening is found which gives the best effect.

[2] The differentiation between the starch-grains, the other cell-contents, and the cell-walls will appear better in the drawings if the starch-grains are sketched with blue ink or a fine blue pencil.

in the seeds in bulk, but that it is inclosed in little chambers or *cells.*[1]

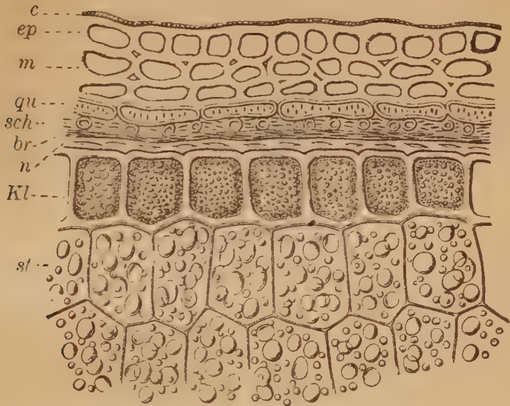


FIG. 11. — Section through Exterior Part of a Grain of Wheat.
c, cuticle or outer layer of bran ; *ep*, epidermis ; *m*, layer beneath epidermis ; *qu*, *sch*, layers of hull next to seed-coats ; *br*, *n*, seed-coats ; *Kl*, layer containing proteid grains ; *st*, cells of the endosperm filled with starch. (Greatly magnified.)

32. *Absorption of Starch from the Cotyledons.* — Examine with the microscope, using a medium power, soaked beans and the cotyledons from seedlings that have been growing for three or four weeks. Stain the sections with iodine solution, and notice how completely the clusters of starch-grains that filled most of the cells of the unsprouted cotyledons have disappeared from the shriveled cotyledons of the seedlings. A few grains may be left, but they have lost their sharpness of outline, and resemble somewhat the "corroded" starch-grains of Indian corn shown in Fig. 12.

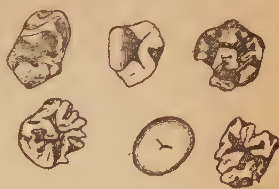


FIG. 12. — Corroded Starch-Grains from Endosperm of Sprouted Indian Corn. The seedling over three inches high. The middle starch-grain of the lower row is uncorroded. (Greatly magnified.)

[1] The teacher will do well to sketch with the camera lucida a few divisions of the stage-micrometer and some cells of the seed, with contained starch-grains, on a piece of cardboard that may be passed round the class to give a precise idea of the actual and the apparent size of the objects examined.

33. *Oil.*—The presence of oil in any considerable quantity in seeds is not as general as is the presence of starch, though in many common seeds there is a good deal of it.

34. ***Experiment 11.**** — To a few ounces of ground flaxseed add an equal volume of ether or benzine. Let it stand ten or fifteen minutes and then filter. Let the liquid stand in a good draught till it has lost the odor of the ether or benzine.

What have you obtained ?

Of what use would it have been to the plant ?

If the student wishes to do this experiment at home for himself, he should bear in mind the following :

Caution. —Never handle benzine or ether near a flame or stove.

35. *Albuminous Substances.* — Albuminous substances, or *proteids*, occur in all seeds, though often only in small quantities. They have nearly the same chemical composition as white of egg and the curd of milk among animal substances, and are essential to the plant, since the living and growing parts of all plants contain large quantities of proteid material.

Sometimes the albuminous constituents of the seed occur in more or less regular grains, Fig. 11.

But much of the proteid material of seeds is not in any form in which it can be recognized under the microscope. One test for its presence is the peculiar smell which it produces in burning. Hair, wool, feathers, leather, and lean meat all produce a well-known sickening smell when scorched or burned, and the similarity of the proteid material in such seeds as the bean and pea to these substances is shown by the fact that scorching beans and similar seeds give off the familiar smell of burnt feathers.

All proteids (and very few other substances) are turned yellow by nitric acid, and this yellow color becomes deeper or even orange when the yellowish substance is moistened with ammonia. Most proteids are turned more or less red

by the solution of nitrate of mercury known as Millon's reagent.[1]

36. ***Experiment 12.*** — Extract the germs from some soaked kernels of corn and bruise them, soak some wheat-germ meal for a few hours in warm water, or wash the starch out of wheat-flour dough, place in a white saucer or porcelain evaporating dish, moisten well with Millon's reagent or with nitric acid and examine after fifteen minutes.[2]

37. *Other Constituents of Seeds.* — Besides the substances above suggested, a variety of others occur in different seeds. Some of these are of use in feeding the seedling, others are of value in protecting the seed itself from being eaten by animals or in rendering it less liable to decay. In such seeds as that of the nutmeg, the essential oil which gives it its characteristic flavor probably makes it unpalatable to animals and at the same time preserves it from decay.

Date-seeds are so hard and tough that they cannot be eaten and do not readily decay. Lemon and orange seeds are too bitter to be eaten, and the seeds of the apple, cherry, peach, and plum are somewhat bitter.

The seeds of larkspur, thorn-apple,[3] croton, nux vomica, and many other kinds of plants contain active poisons.

[1] See Appendix B.

[2] It may be found interesting to test a very oily seed, such as the Brazil-nut, for starch, oil, and proteids, and then discuss the question whether any two of these three substances are apparently interchangeable, that is, whether if the plant has one it also needs the other.

[3] Datura, commonly called "Jimpson weed."

CHAPTER IV.

Roots.[1]

38. *Origin of Roots.* — The *primary root* originates from the lower end of the caulicle, as the student learned from his own observations on sprouting seeds. The branches of the primary root are called *secondary roots,* and those which occur on the stem or in other unusual places are known as *adventitious roots.* The roots which form so readily on cuttings of willow, southernwood, Tropæolum, French marigold, geranium (pelargonium), and many other plants, when placed in damp earth or water, are adventitious.

39. ***Experiment 13.*** — Place in water cuttings of any kind of plant which roots readily, and sketch at intervals of two or three days the roots which are formed.

40. *Aerial Roots.* — Those roots which are formed in the air are called *aerial roots.* They serve various purposes, — in some tropical air-plants, Fig. 13, they are known to absorb moisture and other useful substances from the air and to take in water which drips from branches and trunks above them, so that these plants require no soil and grow in mid-air suspended from trees, which serve them merely as supports;[2] many such air-plants are shown in the frontispiece. In such plants as the ivy, Fig. 14, the aerial roots (which are also adventitious) hold the plant to the wall or other surface up which it climbs.

[1] To the plant the root is more important than the stem. The author has, however, treated the structure of the latter more fully than that of the root, mainly because the tissues are more varied in the stem and a moderate knowledge of the more complex anatomy of the stem will serve every purpose.

[2] If it can be conveniently managed, the class will find it highly interesting and profitable to visit any greenhouse of considerable size, in which the aerial roots of orchids and aroids may be examined.

In the Indian corn, roots are sent out from nodes at some distance above the ground and finally descend until they

FIG. 13.—Aerial Roots of an Orchid.

enter the ground. They serve both to anchor the corn-stalk so as to enable it to resist the wind and to supply additional water to the plant.[1] They produce no rootlets until they reach the ground.

[1] Specimens of the lower part of the corn-stalk, with ordinary roots and aerial roots, should be dried and kept for class study.

41. *Water Roots.* — Many plants, such as the willow, readily adapt their roots to live either in earth or in water, and some, like the little floating duckweed, regularly produce roots which are adapted to live in water only. These water roots often show large and distinct sheaths on the ends of the roots, as, for instance, in the water-hyacinth already mentioned. This plant is especially interesting for laboratory cultivation from the fact that it may readily be transferred to moderately damp soil and that the whole plant presents curious modifications when made to grow in earth instead of water.

Fig. 14. — Aerial Adventitious Roots of the Ivy.

42. *Parasitic Roots.*[1] — The dodder, the mistletoe, and a good many other *parasites* live upon nourishment which they steal from other plants. The parasitic roots or *haustoria* form the most intimate connections with the interior portions of the stem or the root, as the case may be, on which the parasite fastens itself.

In the dodder, as is shown in Fig. 15, it is most interesting to notice how admirably the seedling parasite is adapted to the conditions under which it is to live. Rooted at first in the ground, it develops a slender, leafless stem, which, leaning this way and that, no sooner comes into permanent contact with a congenial host (as the supporting plant is called) than it produces haustoria at many points, gives up further growth in its soil roots, and grows rapidly on the

[1] See Kerner and Oliver's *Natural History of Plants*, vol. I, pp. 171–213.

strength of the supplies of ready-made sap which it obtains from the host.

43. *Forms of Roots.* — The primary root is that which proceeds like a downward prolongation directly from the lower end of the caulicle. In many cases the mature root-system of the plant contains one main portion much larger than any of its branches. This is called a taproot, Fig. 16.

Such a root, if much thickened and fleshy, would assume the form shown in the carrot, parsnip, beet, turnip, salsify, or radish. Some plants produce *multiple primary* roots, a cluster proceeding from the lower end of the caulicle at the outset.

Roots of grasses, etc., are thread-like, and known as *fibrous roots*, Fig. 17. If such roots become thickened like those of the dahlia, Fig. 18, they are known as *fascicled roots.*

These often closely resemble tubers, but they may be distinguished from them by their mode of origin,

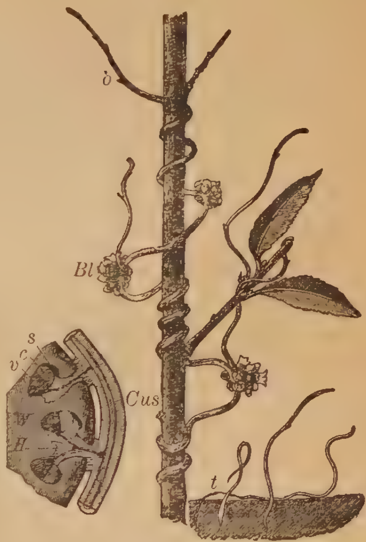


FIG. 15. — Dodder (a European species) Parasitic on the Willow.

The plant is seen encircling a willow twig, into which it sends roots from the warty inner surface of its coils.

b, scale-like leaves; *Bl*, flower-cluster.

At the left is shown the manner in which the parasite *Cus* encircles the host-plant *W*.

The parasitic roots or haustoria *H* penetrate into the parenchyma of the bark and into the fibro-vascular bundles, attaching themselves to the various kinds of tissue, *v*, *c*, *s*, which they find in these.

At the right are seedling dodder plants, the longest one growing at the tip from nourishment which it procures from the dying end next the root.

starting out as expansions of roots, not of underground stems like those of the potato, Fig. 35, and by the irregularity with which buds appear on their surface, if they appear at all.

44. *Structure of Roots.* — The structure of the very young root has been somewhat explained in §§ 17, 18. That of older woody roots of dicotyledons is somewhat more complicated.

FIG. 16.—A Taproot.

FIG. 17.—Fibrous Roots.

FIG. 18.—Fascicled Roots.

Cut thin transverse sections[1] of large and small roots of any hardwood tree[2] and examine them first with a low power of the microscope, as a two-inch objective, to get the general disposition of the parts, then with a higher power, as the half-inch or quarter-inch, for details. With the low power note:

(*a*) The brown layer of outer bark.

(*b*) The paler layer within this.

[1] These may be cut with a razor, flat-ground on one side and hollow-ground on the other, with a scalpel, or with a regular section-knife. The beginner will probably find much difficulty in getting good sections, but will at any rate soon obtain some which are thin enough on the edges to be fairly transparent. A section of very small area will be as good for making out detail of structure as one which extends all the way across the root. Unless a good deal of time is available for laboratory work, the sections will have to be prepared by the teacher, or they may be bought ready-cut. See Appendix C.

[2] Young suckers of cherry, apple, etc., which may be pulled up by the roots, will afford excellent material.

(*c*) The woody cylinder which forms the central portion of the root.

The distinction between (*b*) and (*c*) is more evident when the section has been exposed to the air for a few minutes and changed somewhat in color. It is a good plan to look with the low power first at a thick section, viewed as an opaque object, and then at a very thin one mounted in water or glycerine, and viewed as a transparent object.

Observe the cut-off ends of the *ducts*, or *vessels*, which serve as passages for air and water to travel through; these appear as holes in the

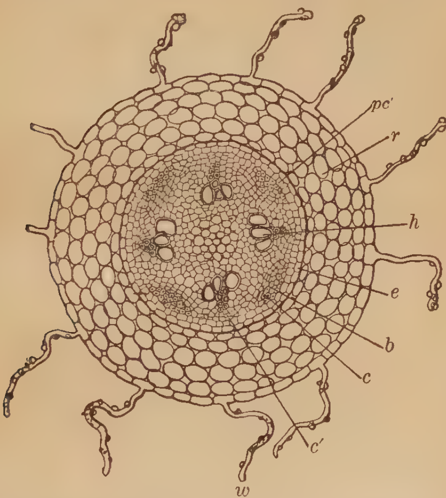


Fig. 19.—Magnified Cross-Section of a very Young Exogenous Root. *w*, root-hairs with bits of sand adhering; *r*, parenchyma cells of the bark; *e*, innermost layer of the bark; *b*, bast; *h*, vessels; *c*, *c*′, cambium.

section, and are much more abundant relatively in the young than in the older and larger portions of the root. Sketch one section of each kind.

Examine with a higher power (100 to 200 diameters), and note the ends of the thick-walled wood-cells. Compare these with Fig. 19.

Notice the many thinner-walled cells composing stripes radiating away from the centre of the root. These bands are the *medullary rays*, whose mode of origin is shown in Fig. 52. Moisten some of the sections with iodine solution,[1] and note where the blue color shows the presence of starch. Split some portions of the root through the middle, cut thin

[1] If the roots are in their winter condition.

sections from the split surface and examine with the high power, with and without staining with iodine.

Notice the appearance of the wood-cells and the ducts as seen in these sections, and compare with Fig. 41.[1]

45. *Structure of Fleshy Roots.* — In some fleshy roots, such as the beet, the nature and relation of the parts is rather puzzling, since they form many layers of tissue in a single season, showing on the cross-section of the root a series of layers which look a little like the annual rings of trees, as shown in Fig. 40.

The structure of the turnip, radish, carrot, and parsnip is simpler.

Cut a parsnip across a little below the middle, and stand the cut end in red ink for 24 hours.

Then examine by slicing off successive portions from the upper end. Sketch some of the sections thus made. In what portion of the root did the colored liquid rise most readily? Cut thin cross-sections of the ink-stained parsnip at several points along its length, and examine first with the low, then with a moderately high power of the microscope. The ring of red ink marks the boundary between bark and wood. Is the main bulk of the parsnip bark or wood? Is this ring marked by the presence of any particular kind of cell? Examine a longitudinal section to help you to answer the question. Cut thin transverse sections from an ink-stained parsnip and notice how the medullary rays run out into the bark. Stain one such section (from the slender portion of the root) with iodine, and sketch it as seen under a low power of the microscope. Where is the starch of this root mainly stored?

46. *Use of the Nourishment stored in Fleshy Roots.* — The parsnip, beet, carrot, and turnip are *biennial plants;* that is, they produce seed during the second summer or fall after they are planted.

The first season's work consists mainly in producing the nourishment which is stored in the roots. To such storage is due their characteristic fleshy appearance. If this root is

[1] The examination of the minute structure of the root is purposely made very hasty, since the detailed study of the structural elements can be made to better advantage in the stem.

planted in the following spring, it feeds the rapidly growing stem which proceeds from the bud at its summit, and an abundant crop of flowers and seed soon follows; while the root, if examined in late summer, will be found to be withered, with its store of reserve material quite exhausted.

The roots of the dahlia, Fig. 20, and of many other *perennials*, or plants which live for many years, contain much stored plant-food. Such plants die to the ground at the beginning of winter, and in spring make a rapid growth from the materials laid up in the roots.

FIG. 20. — Roots of Dahlia, thickened and containing Stored Nourishment.

s, cut-off stems of the plant.

47. *Extent of the Root-System.* — The total length of the roots of ordinary plants is much greater than is usually supposed. They are so closely packed in the earth that only a few of the roots are seen at a time during the process of transplanting, and when a plant is pulled or dug up in the ordinary way, a large part of the whole mass of roots is broken off and left behind. A few plants have been carefully studied to ascertain the total weight and length of the roots. Those of winter wheat have been found to extend to a depth of seven feet. By weighing the whole root-system of a plant and then weighing a known length of a root of average diameter, the total length of the roots may be estimated. In this way the roots of an oat plant have been calculated to measure about 150 feet; that is, all the roots, if cut off and strung together end to end, would reach that distance.

Single roots of large trees often extend horizontally to great distances, but it is not often possible readily to trace the entire depth to which they extend. Roots of oak trees

have been observed penetrating horizontal tunnels in a mine at a depth of about fifty feet.

The total absorbing surface of the roots of a tree must be enormous, since it is greatly increased by the presence of the root-hairs.

48. *Fitness of the Root for its Position and Work.* — The distribution of material in the woody roots of trees and shrubs shows many adaptations to the conditions by which the roots are surrounded. The growing tip of the root, as it pushes its way through the soil, is exposed to bruises; but these are largely warded off by the root-cap. The corky layer which covers the outside is remarkable for its power of preventing evaporation. It must be of use in retaining in the root the moisture which otherwise might be lost, on its way from the deeper rootlets (which are buried in damp soil) through the upper portions of the root-system, about which the soil is often very dry.

49. *Propagation by means of Roots.* — Some familiar plants are usually grown from roots or root-cuttings.

Experiment 14. — Bury a sweet potato or a dahlia root in damp sand, and watch the development of sprouts from adventitious buds. One sweet potato will produce several such crops of sprouts, and every sprout may be made to grow into a new plant. It is in this way that the crop is started wherever the sweet potato is grown for the market.

50. *Absorption of Water by Roots.* — Many experiments on the cultivation of corn, wheat, oats, beans, peas, and other familiar plants in water have proved that some plants, at any rate, can thrive very well on ordinary lake, river, or well water, together with the food which they absorb from the air (Chapter XII). Just how much water some kinds of plants give off (and therefore absorb) per day will be discussed when the uses of the leaf are studied. For the present it is sufficient to state that even an annual plant during its life-time absorbs through the roots very many times its own

weight of water. Grasses have been known to take in their weight of water in every twenty-four hours of warm, dry weather. This absorption takes place mainly through the root-hairs, which the student has examined as they occur in the seedling plant, and which are found thickly clothing the younger and more rapidly growing parts of the roots of mature plants. Some idea of their abundance may be gathered from the fact that on a rootlet of corn grown in a damp atmosphere, and about $\frac{1}{17}$ inch in diameter, 480 root-hairs have been counted on each hundredth of an inch in length. The walls of the root-hairs are extremely thin, and they are free from any holes or pores which can be seen even by the highest power of the microscope, yet the water of the soil penetrates very rapidly to the interior of the root-hairs. The soil-water brings with it all the substances which it can dissolve from the earth about the plant; and the closeness with which the root-hairs cling to the particles of soil, as shown in Fig. 19, must cause the water which is absorbed to contain more foreign matter than underground water in general does, particularly since the roots give off enough weak acid from their surface to corrode the surface of stones which they enfold or cover.

51. *Osmose.*— The process by which two liquids separated by membranes pass through the latter and mingle is called *osmose.*

52. ***Experiment 15.**** *Osmose in an Egg.* — Cement to the smaller end of an egg a bit of glass tubing about six inches long and about $\frac{3}{16}$ inch inside diameter. Sealing wax or a mixture of equal parts of beeswax and rosin melted together will serve for a cement.

Chip away part of the shell from the larger end of the egg, place it in a wide-mouthed bottle or a small beaker full of water, as shown in Fig. 21, then very cautiously pierce a hole through the upper end of the egg-shell by pushing a knitting-needle down through the glass tube.

Watch the apparatus for some hours and note the gradual rise of the contents of the egg in the tube.[1]

[1] Testing the contents of the beaker with nitrate of silver solution will then show the presence of a little common salt in the water.

The rise of liquid in the tube is evidently due to water making its way through the thin membrane which lines the egg-shell, although this membrane contains no pores visible even under the microscope.

53. ***Experiment 16.*** *Osmose in a Begonia Leaf.* — Place a little powdered sugar on the upper surface of a thick begonia leaf under a small bell glass. Watch for several days to see whether moisture from the inside of the leaf affects the sugar. The *upper* surface of this leaf contains no pores, even of microscopic size.

FIG. 21. — Egg on Beaker of Water, to show Osmose.

54. *Inequality of Osmotic Exchange.* — The nature of the two liquids separated by any given membrane determines in which direction the greater flow shall take place.

If one of the liquids is pure water and the other is water containing solid substances dissolved in it, the greater flow of liquid will be away from the pure water into the solution, and the stronger or denser the latter, the more unequal will be the flow. This principle is well illustrated by the egg-osmose experiment. Another important principle is that substances which readily crystallize, like salt or sugar, pass rapidly through membranes, while jelly-like substances, like white of egg, can hardly pass through them at all.

55. *Osmose in Root-Hairs.* — It is very easy to understand, from the principles just stated, that the soil-water (which is like ordinary spring or well water), separated by the delicate walls of the root-hairs and a thin lining of jelly-like living matter from the more or less sugary or mucilaginous sap inside them, will pass rapidly into the plant, while very little of the sap will come out. Probably most of the selective action, which causes the flow of liquid through the root-hairs to be almost wholly inward, is due mainly to the living layer of proteid material known as *protoplasm* (Chapter XIII), which

covers the inner surface of the cell-wall of the root-hair. When the student has learned how active a substance protoplasm often shows itself to be, he will not be astonished to find it behaving almost as though it were possessed of intelligence and will. Traveling by osmotic action from cell to cell, a current of water derived from the root-hairs is forced up through the roots and into the stem, just as the contents of the egg was forced up into the tube shown in Fig. 21.

56. *Root Pressure.* — The force with which the upward flowing current of water presses may be estimated by attaching a mercury gauge to the root of a tree, or the stem of a small sapling. This is best done in early spring after the thawing of the ground, but before the leaves have appeared. In Fig. 22 the apparatus is shown attached to the stem of a dahlia. The large glass tube *W*, filled with mercury up to the level *g* and with water from *g* to near *s*, is fastened tightly to the cut stem at *s*. As water absorbed by the roots is forced over into *W*, the mercury level in *Q* will rise higher and the difference of level in the two mercury-columns will measure the root pressure. For every foot of difference in level there must be a pressure of nearly six pounds per square inch on the stump at the base of the tube *g*.

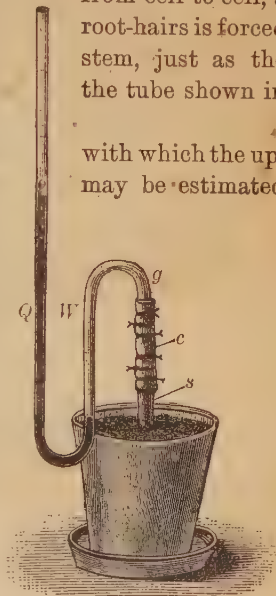


FIG. 22. — Apparatus for Measurement of Root Pressure.

s, cut-off stem of dahlia; *c*, a piece of rubber tubing slipped over the stump *s* and the glass tube *g* and tied fast; *g*, bent glass tube; *W*, water (sap forced up by the roots); *Q*, mercury-column sustained by the root pressure.

A black-birch root tested in this way at the end of April has given a root pressure of 37 pounds to the square inch. This would sustain a column of water about 86 feet high.

CHAPTER V.

Stems.

57. *What the Stem is.* — The work of nourishing the plant is done mainly by the roots and the leaves. The stem is that part or organ of the plant which serves to bring roots and leaves into communication with each other. In most flowering plants the stem also serves the important purpose of lifting the leaves up into the sunlight, where alone they best can do their especial work.

The student has already, in Chapter II, learned something of the development of the stem and the seedling; he has now to study the external appearance and internal structure of the mature stem. Much in regard to these can conveniently be learned from the examination of twigs and branches of our common forest trees in their winter condition.

58. *The Horse-Chestnut Twig.*[1] — Procure a twig of horse-chestnut eighteen inches or more in length. Make a careful sketch of it, trying to bring out the following points:

(1) The general character of the bark.

(2) The large leaf-scars (marking the places where the bases of leaf-stalks were attached) and the number and position of the dots on these scars.

(3) The ring of narrow scars around the stem in one or more places,[2] and the different appearance of the bark above and below such a ring.

See Fig. 23, *b sc.*

(4) The buds at the upper margin of each leaf-scar and the strong terminal bud at the end of the twig.

[1] Where the buckeye is more readily obtained it will do very well. Hickory twigs answer the same purpose, and the latter is a more typical form, having alternate buds. The magnolia or the tulip tree will do. The student should (sooner or later) examine at least one opposite and one alternate-leaved twig.

[2] A very vigorous shoot may not show any such ring.

(5) The flower-bud scar, a concave impression, to be found in the angle produced by the forking of two twigs, which form, with the branch from which they spring, a Y-shaped figure.

(6) (On a branch larger than the twig handed round for individual study) the mode of origin of the twigs from the branch; — make a separate sketch of this.

The portion of stem which originally bore any two pairs of leaves is called a *node*, and the portions of stem between nodes are called *internodes*.

Describe briefly in writing alongside the sketches any observed facts which the drawings do not show.

If your twig was a crooked, rough-barked, and slow-growing one, exchange it for a smooth, vigorous one and note the differences. Or if you sketched a quickly grown shoot, exchange for one of the other kind.

Fig. 23. — A Quickly grown Twig of Cherry, with Lateral and Terminal Buds in October.

b sc, bud-scale scars. All above these scars is the growth of the spring and summer of the same year.

Answer the following questions:

(*a*) How many inches did your twig grow during the last summer?
How many in the summer before?
How do you know?
How many years old is the whole twig given you?

(*b*) How were the leaves arranged on the twig?
How many leaves were there?
Were they all of the same size?

(*c*) What has the mode of branching to do with the arrangement of the buds? with the flower-bud scars?

(*d*) The dots on the leaf-scars mark the position of the bundles of ducts and wood-cells which run from the wood of the branch through the leaf-stalk up into the leaf.

59. *Twig of Beech.* — Sketch a vigorous young twig of beech in its winter condition, noting particularly the respects in which it differs from the horse-chestnut. Describe in writing any facts not shown in the sketch. Notice that the buds are not opposite, nor is the next one above

any given bud found directly above it, but part way round the stem from the position of the first one. Ascertain, by studying several twigs, which bud is above the first and how many turns round the stem are made in passing from the first to the one directly above it.

Observe with especial care the difference between the beech and the horse-chestnut in mode of branching, as shown in a large branch provided for the study of this feature.

FIG. 24.—Opposite Branching in a very Young Sapling of Ash.

60. *Relation of Leaf-Arrangement to Branching.*[1] —This difference depends on the fact that the leaves of the horse-chestnut were arranged in pairs, on opposite sides of the stem, while those of the beech were not in pairs. Since the buds are found at the upper edges of the leaf-scars, and since most of the buds of the horse-chestnut and the beech are leaf-buds and destined to form branches, the mode of branching and ultimately the form of the tree must depend largely on the arrangement of leaves along the stem.

61. *Opposite Branching.* — In trees the leaves and buds of which are opposite, the tendency will be to form twigs in two rows about at right angles to each other along the sides of the branch, as shown in Fig. 24.

[1] The teacher will do well to make constant use, in the study of branches and buds, of Miss Newell's *Outlines of Lessons in Botany*, Part I. The student can make out for himself, with a little guidance from the teacher, most of the points

This arrangement will not usually be perfectly carried out, since some of the buds may never grow, or some may grow much faster than others and so make the plan of branching less evident than it would be if all grew alike.

62. *Alternate Branching.* — In trees like the beech the twigs will be found to be arranged in a more or less regular spiral line about the branch. This, which is known as the *alternate* arrangement (Fig. 25), is more commonly met with in trees and shrubs than the *opposite* arrangement. It admits of many varieties, since the spiral may wind more or less rapidly round the stem. In the apple, pear, cherry, poplar, oak, and walnut, one passes over five spaces before coming to a leaf which is over the first, and in doing this it is necessary to make two complete turns round the stem, Fig. 77.

Fig. 25.—Alternate Branching in a very Young Apple Tree.

63. *Growth of the Terminal Bud.* — In some trees the terminal bud from the very outset keeps the leading place, and the result of this mode of growth is to produce a slender, upright tree, with an *excurrent* trunk like that of Fig. 26, II.

In such trees as the apple and many oaks the terminal bud has no preëminence over others, and the form of the tree is round-topped and spreading, *deliquescent* like Fig. 26, I.

Most of the larger forest trees are intermediate between these extremes, like Fig. 27.

which Miss Newell suggests. If the supply of material is abundant, the twigs employed in the lessons above described need not be used further, but if material is scanty, the study of buds may at once be taken up.

Branches get their characteristics to a considerable degree from the relative importance of their terminal buds. If these are mainly flower-buds, as is the case in the horse-chestnut, the tree is characterized by frequent forking, and has no long horizontal branches.

If the terminal bud keeps the lead of the lateral ones, but the latter are numerous and most of them grow into slender twigs, the delicate spray of the elm and many birches is produced, Fig. 28.

I. II.

FIG. 26.—I, An American Elm with Deliquescent Trunk. II, Cottonwood Poplars with Excurrent Trunks.

The general effect of the branching depends much upon the angle which each branch or twig forms with that one from which it springs. The angle may be quite acute, as in the birch; or more nearly a right angle, as in the ash, Fig. 24.

It is these differences that help to give to leafless woods in winter their unending variety and beauty.

64. *Indefinite Annual Growth.* — In most of the forest trees, and in the larger shrubs, the wood of the branches is matured and fully developed during the summer, and pro-

tected buds are formed on the twigs to their very tips. In other shrubs — for example, in the sumach, the raspberry, and blackberry — the shoots continue to grow until their soft and partly matured tips are killed by the frost. Such a mode of growth is called *indefinite annual growth*, to distinguish it from the *definite annual growth* of most trees.

65. *Trees, Shrubs, and Herbs.* — Plants of the largest size, with a main trunk of a woody structure, are called *trees*. *Shrubs* differ from trees in their smaller size, and generally in their more forking and divided stem. The witch-hazel, the dogwoods, and the alders, for instance, are most of them classed as shrubs for this reason, though in height some of them equal the smaller trees. Some of the smallest shrubby plants, like the blueberry, the wintergreen, and the trailing arbutus, are only a few inches in height, but are ranked as shrubs because their woody stems do not die quite to the ground in winter.

FIG. 27. — A White-Oak Tree, with Trunk somewhat Deliquescent.

Herbs are plants whose stems above ground die every winter.

66. *Annual, Biennial, and Perennial Plants.* — *Annual* plants are those which live but one year, *biennials* those which live two years or nearly so (see § 46).

Some annual plants may be made to live over winter, flowering in their second summer. This is true of winter wheat and rye among cultivated plants.

Perennial plants live for a series of years. Many kinds of trees last for centuries. The Californian giant redwoods, or Sequoias, which reach a height of over 300 feet under favorable circumstances, live nearly 2000 years; and some monstrous cypress trees found in Mexico were thought by Professor Asa Gray to be from 4000 to 6000 years old.

FIG. 28.—Twigs and Branches of the River Birch.

67. *Stemless Plants.* — The so-called *stemless plants*, like the dandelion, Fig. 29, and some violets, are not really stemless at all, but send out their leaves and flowers from a very short stem which hardly rises at all above the surface of the ground.

Now, as will be shown later (§ 241) plants live subject to a very fierce competition among themselves and exposed to almost constant attacks from animals.

Any plant which can grow in safety under the very feet of grazing animals will be especially likely to make its way in the world, since there are many places where it can flourish while ordinary plants would be destroyed. The bitter, stemless dandelion, which is almost uneatable for most animals, unless cooked, which lies too near the earth to be fed upon by grazing animals, and which bears being trodden on with impunity, is a type of a large class of hardy weeds.

And while plants with long stems find it to their account to reach up as far as possible into the sunlight, the cinquefoil,

the white clover, the dandelion, the spurges, the knot-grass, and hundreds of other kinds of plants have found safety in hugging the ground.

68. *Climbing and Twining Stems.*[1] — Since it is essential to the health and rapid growth of most plants that they should have free access to the sun and air, it is not strange that many should resort to special devices for lifting themselves above their neighbors. In tropical forests, where the darkness of the shade anywhere beneath the tree-tops is so great that few flowering plants can thrive in it, the climbing plants or *lianas* often run like great cables for hundreds of

FIG. 29. — The Dandelion; a so-called Stemless Plant.

feet before they can emerge into the sunshine above, as those shown in the frontispiece have probably done. In temperate climates no such remarkable climbers are found, but many plants raise themselves for considerable distances. The principal means to which they resort for this purpose are:

(1) Producing roots at many points along the stem above ground and climbing on suitable objects by means of these, as in the English ivy, Fig. 14.

[1] See Kerner and Oliver's *Natural History of Plants*, vol. I, p. 669.

(2) Laying hold of objects by means of tendrils or *twining* branches or *leaf-stalks*, as shown in Figs. 30, 31.

(3) Twining about any slender upright support, as shown in Fig. 32.

69. *Tendril-Climbers.*—The plants which climb by means of tendrils are very interesting subjects for study, but they cannot usually be managed very well in the schoolroom. Continued observation soon shows that the tips of tendrils sweep slowly about in the air until they come in contact with some object about which they can coil themselves. After the tendril has taken a few turns about its support, the free part of the tendril coils into a spiral and thus draws the whole stem toward the point of attachment as shown in Fig. 30. Some tendrils are leaves or stipules, as shown in Fig. 91; others are modified stems.

FIG. 30.—Coiling of a Tendril of Bryony. x, portion coiled around a twig; w, w', places where direction of coiling reverses; u, uncoiled portion of tendril.

70. *Twiners.*—Only a few of the upper internodes of the stem of a twiner are concerned in producing the movements of the tip of the stem. This is kept revolving in an elliptical or circular path until it encounters some roughish and not too stout object, about which it then proceeds to coil itself. The direction of the coiling varies in different kinds of climbers, some following the course shown in the figure of the hop on the next page, others, as the morning-glory, taking the opposite course.

71. *Underground Stems.*—Stems which lie mainly or wholly underground are of frequent occurrence and of many kinds.

In the simplest form of *rootstock*, Fig. 33, such as is found in some mints and in many grasses and sedges, the real nature of the creeping stem is shown by the presence upon its surface of many scales which are reduced leaves. In the stouter rootstocks, like that of the iris, Fig. 34, this stem-like character is less evident. The potato is an excellent example of the short and much thickened underground stem known as a *tuber*.

It may be seen from Fig. 35 that the potatoes are none of them borne on true roots, but only on subterranean branches, which are stouter and more cylindrical than most of the roots.

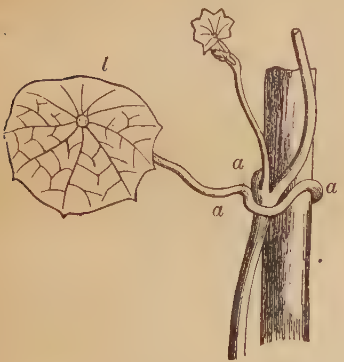


FIG. 31.—Coiling of Petiole of Dwarf Tropæolum; *l*, leaf; *a*, petiole.

FIG. 32.—Twining Stem of Hop.

Bulbs, whether coated like those of the onion or scaly like those of the hyacinth, Fig. 36, are merely very short and stout underground stems, covered with closely crowded scales or layers which represent leaves or the bases of leaves, Fig. 37.

The variously modified forms of underground stem just discussed, illustrate in a marked way the storage of nourish-

ment during the winter (or the rainless season, as the case may be) to secure rapid growth during the active season. It is interesting to notice that nearly all of the early-flowering herbs in temperate climates, like the crocus, the snowdrop, the spring-beauty, the tulip, and the skunk-cabbage, owe their early-blooming habit to richly stored underground stems of some kind, or to thick, fleshy roots.

FIG. 33. — Rootstock of a Sedge.
The young, advancing shoot is seen at the left; in the centre is a cluster of leaves rising above ground; further to the right similar clusters would be found springing from the same rootstock.

72. *Condensed Stems.* — The plants of desert regions require above all protection from the extreme dryness of the surrounding air, and, usually, from the excessive heat of the sun. Accordingly, many desert plants are found quite destitute of ordinary foliage, exposing to the air only a small surface of green rind. In the melon-cactuses, Fig. 38, the stem appears reduced to the shape in which the

FIG. 34. — Roots, Rootstocks, and Leaves of Iris.

FIG. 35. — Part of a Potato Plant.

The dark tuber in the middle is the one from which the plant has grown.

least possible surface is presented by a plant of given bulk, — that is, in form. Other cactuses are more or less cylindrical or prismatic, others still consist of flattened joints, but all agree in offering much less surface to the sun and air than is exposed by an ordinary leafy plant.

73. *Leaf-like Stems.* — The flattened stems of some kinds of cactus (especially the common, showy *Phyllocactus*) are sufficiently like fleshy leaves, with their dark green color and imitation of a midrib, to pass for leaves among people who are not botanists. There are, however, a good many cases in which the stem takes on a more strikingly leaf-like form. The common asparagus sends up in spring shoots that bear large scales which are really reduced leaves. Later in the season, what seem like thread-like leaves cover the much-branched mature plant, but these green threads are actually minute branches, which per-

I. II.

FIG. 36. — I, Bulb of Hyacinth. II, the same split lengthwise.

form the work of leaves. The familiar greenhouse climber, wrongly known as smilax (properly called Myrsiphyllum), bears a profusion of what appear to be delicate green leaves, Fig. 39. Close study, however, shows that these are really short, flattened branches, and each of them springs from the axil of a true leaf, *l*, in the form of a minute scale. Some-

FIG. 37.—Longitudinal Section of an Onion Leaf. *z*, thickened base of leaf, forming a bulb-scale; *s*, thin sheath of leaf; *l*, *i*, blade of the leaf; *h*, hollow interior of blade.

FIG. 38.—A Melon-Cactus.

times, as shown at *f*, a flower and a leaf-like branch spring from the axil of the same scale.

Branches which, like those of the Myrsiphyllum, so closely resemble leaves as to be almost indistinguishable from them are called *cladophylls*.

74. *Modifiability of the Stem.*—The stem may, as in the tallest trees, in the great lianas of South American forests, seen in the frontispiece, or the rattan of Indian jungles, reach a length of many hundred feet, or it may in such "stemless"

plants as the primrose and the dandelion be cut down to a fraction of an inch in length. It may take on apparently root-like forms, as in many grasses and sedges, or become thickened by underground deposits of starch and other plant-food, as in the iris, the potato, and the crocus. Condensed forms of stem may exist above ground, or, on the other hand,

FIG. 39. — Stem of "Smilax" (Myrsiphyllum).
l, scale-like leaves; *Cl*, cladophyll, or leaf-like branch, growing in the axil of the leaf; *ped*, flower-stalk, growing in the axil of a leaf.

branches may be flat and thin enough closely to imitate leaves. In short, the stem manifests great readiness in adapting itself to the most varied conditions of existence.

CHAPTER VI.

Structure of the Stem.

Stem of Dicotyledonous Plants.

I.

75. *General Structure.*—Cut smooth, rather thick, sections from a twig of apple one year old. Place in focus under the magnifying glass and make a sketch to show the relative position and amount of bark, wood, and pith.

From a twig of cherry a year or two old peel off the brown outer coating. This is the *corky layer* of the bark, more distinct in the cherry tree than in the apple.

Notice on the outer surface of the twig the rough oval or lens-shaped spots. These are the *lenticels*, spots in which the inner and more porous layers of the bark protrude through the corky layer and allow air to penetrate to the interior of the branches.[1] Notice the *green layer* or middle bark in the peeled portion of the cherry twig, and expose this layer in the apple twig by carefully scraping off the corky layer.

Cut off, as smoothly as possible, a small branch of hickory and one of white oak above and below each of the rings of scars already mentioned (§ 58), and count the rings of wood above and below each ring of scars.

How do the numbers correspond? What does this indicate?

Count the rings of wood on the cut-off ends of large billets of some of the following woods: locust, chestnut, sycamore, oak, hickory.

Do the successive rings of the same tree agree in thickness?

Why? or why not?

Does the thickness of the rings appear uniform all the way round the stick of wood? If not, the reason in the case of an upright stem (trunk) is perhaps that there was a greater spread of leaves on the side where the rings are thickest[2] or because there was unequal pressure, caused by bending before the wind.

Do the rings of any one kind of tree agree in thickness with those of all the other kinds? What does this show?

In all the woods examined look for:

(*a*) Contrasts in color between the heartwood and the sapwood.[3]

[1] See Gregory's *Plant Anatomy*, pp. 138–141.

[2] See § 145.

[3] This is admirably shown in black walnut, barberry, and osage orange.

(*b*) The narrow lines running in very young stems pretty straight from pith to bark, in older wood extending only a little of the way from centre to bark, the *medullary rays*, shown in Fig. 40.[1]

(*c*) The wedge-shaped masses of wood between these.

(*d*) The holes which are so grouped as to mark the divisions between successive rings. These holes indicate the cross-sections of *vessels* or *ducts* (§ 82). Note the distribution of the vessels in the rings to which they belong, compare this with Figs. 40, 41, and decide at what season of the year the largest ducts are mainly produced. Cut off a grapevine several years old and notice the great size of the vessels. Examine the smoothly planed surface of a billet of red oak that has been split through the middle of the tree (quartered oak), and note the large shining plates formed by the medullary rays.

Look at another stick that has been planed away from the outside until a good-sized flat surface is shown, and see how the medullary rays are here represented only by their edges.

FIG. 40. — Cross Section of Oak Wood as seen with the Magnifying Glass.
J, *J*, the annual rings.[2]

II.

76. *Details of Structure; Cross-Section.* — Cut from shoots of the apple tree, ranging in age from one to five years, a number of sections. These should be as thin as they can be made without breaking up. It will save time to make at one time a good many sections of any woody part of the plant that is to be examined.[3]

For examination with the lowest powers, cylinders ¼ to ½ inch long cut smoothly from the twig to be examined, and viewed as opaque objects, will answer well.

[1] These and many other important things are admirably shown in the thin wood-sections furnished for $4 per set of 24 by R. B. Hough, Lowville, N. Y.

[2] The shading in fine lines at *J* would be rendered more naturally by dots.

[3] If time allows, the students should cut their own sections: frequently this will be impracticable. Sections not needed for the current lesson may be put in 50 per cent alcohol or other preservative fluid in wide-mouthed bottles *carefully labeled* and kept for future use. For a list of sections see Appendix C.

Examine each thin section first with a power of about 25 diameters, then with a power of from 100 to 200 diameters. With the lower power, sketch a one-year-old section, labeling in your sketch :

(*a*) The corky layer of the bark.
(*b*) The green layer.
(*c*) The masses of bast fibres.
(*d*) The wood, with the medullary rays and vessels.
(*e*) The pith.

FIG. 41.—Cross-Section of a Three-year-old Linden Twig. (Much magnified.) *P*, epidermis and corky layer of the bark; *Phl*, bast; *C*, cambium layer; *JR*, annual rings of wood.

After examining this section with the higher power and noting particularly the appearance of the wood-cells, replace it by a section of stem at least four years old.

Sketch this as seen with the low power, then substitute the higher power and study the *inner bark*, noting especially the masses of very thick-walled *bast-cells*.

What are the principal differences between the structure of the apple twig, so far as you have examined it, and the structure of a linden twig, as shown in Fig. 41?

Make a thin section of the stem of grapevine or elder a year or two old and study the pith with a power of 50 or 100 diameters. Sketch it.

FIG. 42.

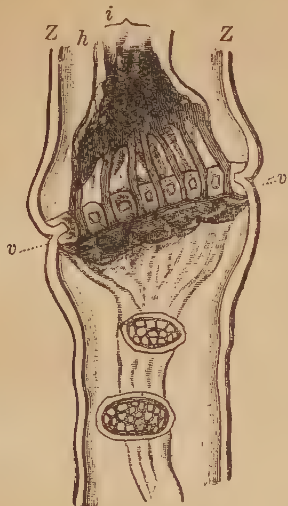


FIG. 43.

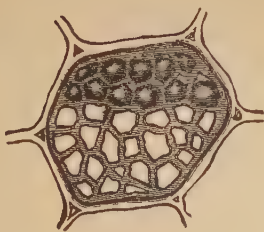


FIG. 44.

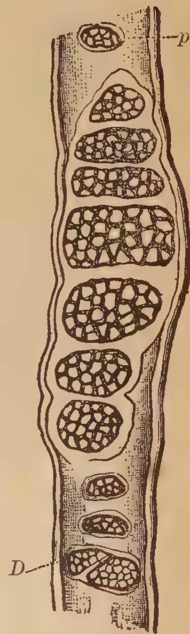


FIG. 45.

FIG. 42. — Portion of a Sieve-Tube, showing one whole cell and parts of two others.
FIG. 43. — Longitudinal Section through Sieve-Tube of the Gourd. *Z*, cell-wall; *h*, outer coating of protoplasmic cell-contents *i*; *v*, sieve-plate.
FIG. 44. — Transverse Section of a Sieve-Plate like that shown at *v*.
FIG. 45. — Part of Longitudinal Section of a Sieve-Tube of Linden, showing sieve-plates *p* on the sides of the tube (two of which are also shown on Fig. 43).
(All greatly magnified.)

77. *Sieve-Tubes.* — Grouped together with the bast fibres of the stem there occur a peculiar and very important set of vessels called *sieve-tubes.* The student cannot easily make these out from sections of ordinary stems, but it is not difficult to understand their structure in a general way. These tubes arise from the partial union of large cells which stand in rows, united end to end, as shown in Figs. 42, 43. The partitions between adjacent cells gradually become perforated with holes, forming a *sieve-plate,* like that shown in Fig. 44. Sometimes the walls of sieve-tubes are more or less fully covered with perforations, as shown in Fig. 45.

Continuity of the Living Cell-Contents. — It was formerly supposed that cells of plants were entirely shut off from each other while living. Recently, careful investigations have shown that very generally, especially in the expanded bases of the leaf-stalks of leaves which move of their own accord and in sieve-cells, there is a direct connection of the contents of one cell with another. The *protoplasm,* or semi-fluid layer with which all active cells are lined, and in which their life and working-power resides (Chapter XIII), extends in delicate threads through the cell walls, and connects in all directions with the protoplasm of other cells.

FIG. 46. — Side View of Part of one of the Medullary Rays of Maple Wood. (Much magnified.)

78. *Longitudinal Section of the Stem.* — The knowledge of stem-structure that can be gained from a longitudinal section of any kind of wood depends upon the way in which the section is cut; that is, whether it is at right angles to the annual rings (*radial section*), or parallel to the rings (*tangential section*). The wood-cells, of which the student has in the cross-section seen only the cut-off ends, appearing as circular or

oval figures, now show the whole length of the cell, and he may study the way in which they interlock at the ends.

In the radial section the medullary rays will frequently look somewhat like portions of brickwork, as shown in Fig. 46.

In the tangential section, only the cut-off edges of the medullary rays will be seen, as shown in Fig. 47.

79. *Separate Wood-Cells.* — The complete outline of wood-cells and bast-cells is most easily made out by examining cells which have been separated from each other by soaking wood or bark, as the case may be, in a mixture of chlorate of potash and nitric acid until it can be easily picked to pieces in water and viewed under the microscope. In this way such cells as those shown in Fig. 48 may be isolated and studied.

FIG. 47. — Longitudinal Section of Mahogany at right angles to the Medullary Rays, showing their cut-off ends.[1] (Much magnified.)

80. *Ducts of Various Forms.* — In most of the hard-woods the ducts are poorly shown in the longitudinal section, since they usually become much split and broken in the process of cutting the section.

Study and sketch some of the following, as seen under a moderately high power:

Radial longitudinal section of wood of tulip tree, longitudinal section of stem of bracken fern (Pteris), stem of castor-oil plant (Fig. 49), of peduncle of banana, or of root of chicory or licorice.

81. *Kinds of Tissue.* — The student has now become acquainted with a few of the many kinds of cells found in plants, and has begun to see how they are grouped together

[1] The apparently vacant spaces at the ends of the lens-shaped sections of the medullary rays are in most woods filled with cells, like the rest of the section.

in masses to make up the bulk of the plant. Masses of cells which have a common work to do are called *tissues.*[1] Two of the most important forms of tissue are *parenchyma* and *prosenchyma.* Parenchyma is found in the seed, in the bark (constituting the greater portion of all young bark), in the medullary rays and the pith, and in the leaf. Parenchyma cells are usually roundish or somewhat cubical or twelve-sided in shape.

From the fact that a sphere surrounded by other spheres is touched by twelve others, parenchyma cells, which begin their existence in a somewhat globular form, often end by growing approximately twelve-sided from the pressure of their neighbors. Prosenchyma cells are long, often thick-walled, and interlock at the ends, so as to leave but few and small intercellular spaces. They form the fibrous part of bark and of most kinds of wood.

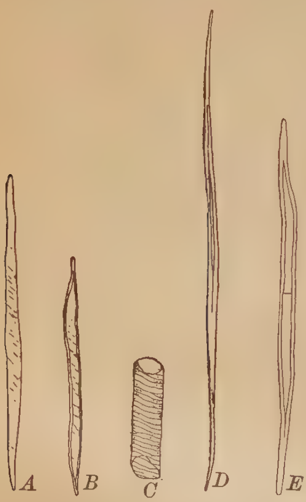


FIG. 48. — *A*, *B*, *C*, *D*, Isolated Wood-Cells and Bast-Cells of Linden.

A, *B*, wood fibres; *C*, piece of a vessel; *D*, bast fibre; *E*, a partitioned, woody fibre from European ivy. (Much magnified.)

82. *Uses of the Components of the Stem.* — There is a marked division of labor among the various groups of cells that make up the stem of ordinary dicotyledons, particularly in the stems of trees, and it will be best to explain the uses of the kinds of cells as found in trees, rather than in herbaceous plants.

A few of the ascertained uses of the various tissues are these:

[1] See Gregory's *Plant Anatomy*, Chapter IV.

The pith forms a large part of the bulk of very young shoots, since it is a part of the fundamental tissue amid which the fibro-vascular bundles arise. In mature stems it becomes rather unimportant, though it often continues for a long time to act as a storehouse of nourishment.

The medullary rays, in the young shoot, serve as a channel for the transference of water and plant-food in a liquid form across the stem, and they often contain much stored nourishment.

The vessels carry water and air through the stem.

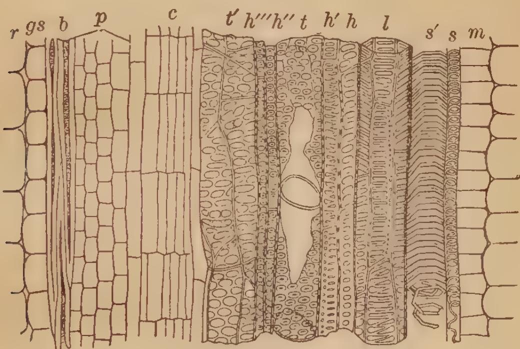


FIG. 49. — Longitudinal Section of a Fibro-Vascular Bundle of the Castor-Oil Plant. *r*, *gs*, *b*, *p*, various layers of the bark; *c*, cambium; *t* *l*, *s*, *s'*, various kinds of vessels; *h*, *h'*, *h''*, *h''*, wood-cells; *m*, pith. (Much magnified.)

The wood-cells of the heartwood are useful only to give stiffness to the stem. Those of the sapwood in addition to this work have to carry most of the water from the roots to the leaves and other distant portions of the plant.

The cambium layer is the region in which the annual growth of the tree takes place, § 84.

The most important portion of the inner bark is that which consists of sieve-tubes, for in these digested and elaborated plant-food is carried from the leaves toward the roots.

The green layer of the bark in young shoots does much toward collecting and preparing the food of the plant from air and water, but this work may be best explained in connection with the study of the leaf, Chapter XII.

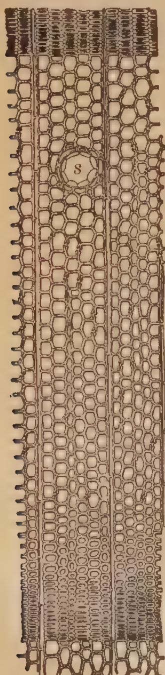


Fig. 50.—Cross-Section of Fir Wood.

s, a resin passage ; *m*, medullary rays. (Much magnified.)

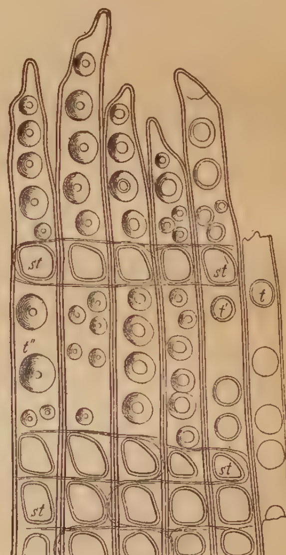


Fig. 51.—Longitudinal Radial Section through a Rapidly Growing Young Branch of Pine.

t, *t'*, *t"*, bordered pits on wood-cells ; *st*, large pits where medullary rays lie against wood-cells. (Much magnified.)

Finally, the corky layer of the bark serves to a considerable extent as a protection against sudden changes of temperature and aids greatly in preventing evaporation of water on its way along the stem.

83. *Stem of Conifers.*[1] — Sketch the end of a cut-off billet of hard pine or red cedar. Study the cut surface with a magnifying glass and decide whether any of the parts readily found in the wood of the coarser-grained hard-woods are absent from coniferous wood.

Under a power of 100 or more diameters it is easy to see what it is that marks off one annual ring from another.

Study the section, compare it with Fig. 50, and state the difference between spring wood and fall wood.

Sketch the whole cross-section, moderately magnified

Examine longitudinal sections, both radial and tangential, of pine, spruce, fir, or red cedar.[2]

Sketch a radial section and a tangential one, labeling the medullary rays and the cells of the wood, with their circular markings, as shown in Fig. 51.

84. *The Early History of the Stem.* — In the earliest stages of the growth of the stem it consists entirely of thin-walled and rapidly dividing cells. Soon, however, the various kinds of tissue which are found in the full-grown stem begin to appear.

In Fig. 52 the process is shown as it occurs in the castor bean. At *m*, in *B*, is the central column of pith, surrounded by eight fibro-vascular bundles, *fv*, each of which contains a number of ducts arranged in a pretty regular manner and surrounded by the forerunners of the true wood-cells.

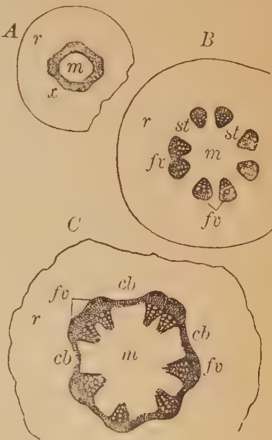


FIG. 52. — Transverse Section through the Caulicle of the Castor-Oil Plant at Various Stages.

A, after the root has just appeared outside the testa of the seed; *B*, after the caulicle is nearly an inch long; *C*, at the end of germination; *r*, cortex (undeveloped bark); *m*, pith; *st*, medullary rays; *fv*, fibro-vascular bundles; *cb*, layer of tissue which is to develop into cambium. (Considerably magnified.)

[1] That is, of the cone-bearing trees (mostly evergreens), such as the pines, spruces, cedars, larches, and so on.

[2] Pine shows the large circular pits very plainly, while red cedar shows the medullary rays most clearly, since nearly all its red color lies in these.

In *C*, the section shows a considerable advance in growth: the fibro-vascular bundles are larger and are now connected by a rapidly growing layer of tissue, *cb*.

As growth continues, this layer becomes the *cambium layer*, composed of thin-walled and rapidly dividing cells, as shown in Fig. 41.

85. *Secondary Growth.* — From the inside of the cambium layer the wood-cells and ducts of the mature stem are produced, while from its outer circumference the new layers of the bark proceed. From this mode of increase, the stems of dicotyledonous plants are called *exogenous*, that is, outside-growing. The presence of the cambium layer on the outside of the wood in early spring is a fact well known to the schoolboy who pounds the cylinder cut from an elder, willow, or hickory branch until the bark will slip off and so enable him to make a whistle. The sweet taste of this pulpy layer, as found in the white pine, the slippery elm, and the basswood, is a familiar evidence of the nourishment which the cambium layer contains.

With the increase of the fibro-vascular bundles of the wood the space between them, which appears relatively large in Fig. 52, becomes less and less, and the pith, which at first extended freely out toward the circumference of the stem, becomes compressed into thin plates so as to form medullary rays.

These are, as already stated, of use in storing the food which the plant in cold and temperate climates lays up in the summer and fall for use in the following spring, and in the very young stem they serve as an important channel for the transference of fluids across the stem from bark to pith, or in the reverse direction. On account, perhaps, of their importance to the plants, the cells of the medullary rays are among the longest-lived of all vegetable cells, retaining their vitality in the beech tree sometimes, it is said, for more than a hundred years.

After the inter-spaces between the first fibro-vascular bundles have become filled up with wood, the subsequent growth must take place in the manner shown in Fig. 53. The cambium of the original wedges of wood, *fc*, and the cambium, *ic*, formed between these wedges, continues to grow from its inner and from its outer surface, and thus causes a permanent

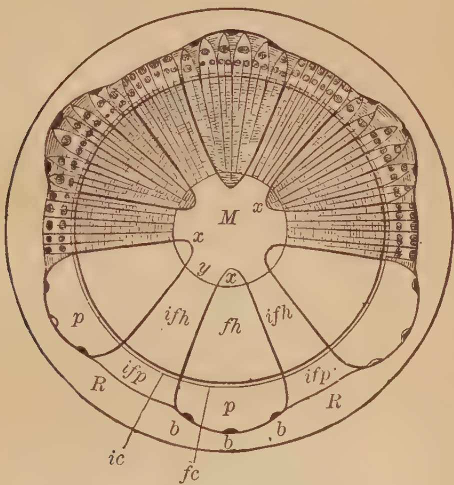


FIG. 53. — Diagram to illustrate Secondary Growth in a Dicotyledonous Stem. *R*, the first-formed bark; *p*, mass of sieve-cells; *ifp*, mass of sieve-cells between the original wedges of wood; *fc*, cambium of wedges of wood; *ic*, cambium between wedges; *b*, groups of bast-cells; *fh*, wood of the original wedges; *ifh*, wood formed between wedges; *x*, earliest wood formed; *M*, pith.

increase in the diameter of the stem and a thickening of the bark, which, however, usually soon begins to peel off from the outside and thus soon attains a pretty constant thickness.[1]

86. *Grafting.* — When the cambium layer of any vigorously growing stem is brought in contact with this layer in

[1] See Gregory's *Plant Anatomy*, Chapter VII.

another stem of the same kind or a closely similar kind of plant, the two may grow together to form a single stem or branch. This process is called *grafting*, and is much resorted to in order to secure apples, pears, etc., of any desired kind. A twig from a tree of the chosen variety is grafted on to any kind of tree *of the same species* (or sometimes a related species), and the resulting stems will bear the wished-for kind of fruit.

STEM OF MONOCOTYLEDONOUS PLANTS.

87. *General Structure.* — Cut across a corn-stalk and examine the cut surface with the magnifying glass. Note the firm rind, composed of the epidermis and underlying tissue, the large mass of pith composing the main bulk of the stem, and the *fibro-vascular bundles*, or groups of wood-cells, bast-cells, and vessels.

In what part of the stem are these bundles most abundant?

Split a portion of the stem lengthwise and notice whether the bundles seem to run straight up and down its length. Every fibro-vascular bundle of the stem passes outward through some node in order to connect with some fibro-vascular bundle of a leaf. This fact being known to the student would lead him to expect to find the bundles bending out of a vertical position more at the nodes than elsewhere. Can this be seen in the stem examined?

Observe the enlargement and thickening at the nodes, and split one of these lengthwise to see whether the tissue within it is exactly like that in the internodes. How may the difference, if any, be explained?

Compare with the corn-stalk a piece of palmetto[1] and notice the similarity of structure, except for the fact that the tissue in the palmetto which answers to the pith of the corn-stalk is much darker-colored and harder than corn-stalk pith. Compare also a piece of rattan.

Cut a thin cross-section of the corn-stalk, examine with a moderately high power of the microscope, and note:

(*a*) The rind, composed largely of hard, thick-walled fibres known as *sclerenchyma* fibres;

(*b*) The fibro-vascular bundles, most abundant near the outside, becoming much more scattered toward the centre of the stem;

(*c*) The pith, occupying the intervals between the fibro-vascular bundles.

[1] The pieces which are sold at the druggists' prepared for nail-brushes will serve the purpose well.

Study the bundles in various portions of the section and notice particularly whether the relative amount of surface in each covered by ducts and by thick-walled wood-cells or sclerenchyma cells is everywhere the same.

On the whole the structure of monocotyledonous stems is much simpler than that of dicotyledonous stems. The bundles which they contain are somewhat similar to those which the exogenous or outside-growing stems of dicotyledons form at a very early period of their growth.

But while in exogens these bundles soon unite into a ring of woody tissue, with a cambium layer outside, capable of continual growth inward and outward, in the *endogenous* or inside-growing stems of monocotyledons this is not the case. True cambium is not formed, but the *procambium* which precedes the mature bark-cells and wood-cells is all transformed into cells of bark or of wood, which attain their full size and are then incapable of giving rise to new cells of any kind. Therefore, the stems of such perennials as palms remain unchanged in diameter year after year. Monocotyledonous stems which do increase in diameter from year to year do so by the introduction of new bundles among the old ones. This growth by interposition of new bundles affords some justification for the name endogenous, often given to the monocotyledonous stem.

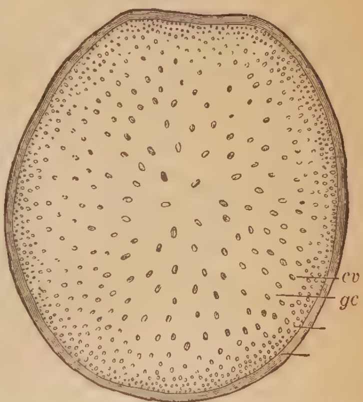


FIG. 54. — Cross-Section of Stem of Indian Corn.

c v, fibro-vascular bundles; *g c*, pithy material between bundles.

88. *Distribution of Material in Monocotyledonous Stems.* — The well-known strength and lightness of the straw of our

smaller grains and of rods of cane or bamboo is due to their form. It can readily be shown by experiment that an iron or steel tube of moderate thickness, like a piece of gas-pipe, or of bicycle-tubing, is much stiffer than a solid rod of the same weight per foot. The oat straw, the cane (of our southern canebrakes), and the bamboo are hollow cylinders: the corn-stalk is a solid cylinder, but filled with a very light pith. The flinty outer layer of the stalk, together with the closely packed sclerenchyma fibres of the outer rind and the frequent fibro-vascular bundles just within this are arranged in a most advantageous way to secure stiffness.

89. *Experiment 17. Rise of Water in Monocotyledonous Stems.* — Place in red ink the ends of pieces cut from any obtainable monocotyledonous stem, as green brier, or young shoots of asparagus,[1] and watch for an hour or two the rise of the coloring-matter, by taking out pieces of stem from time to time and cutting each back from the upper end until the colored portion is reached. Examine the cut surfaces and the outside of each stem with the glass, and describe exactly the distribution of the coloring-matter.

[1] If the class is studying this subject during the autumn, fresh pieces of corn-stalk will be found to give excellent results.

CHAPTER VII.

Living Parts of the Stem; Work of the Stem.

90. In annual plants generally and in the very young shoots of shrubs and trees there are *stomata* or breathing pores which occur abundantly in the epidermis, serving for the admission of air and the escape of moisture, while the green layer of the bark answers the same purpose that is served by the green pulp of the leaf (Chapter XII). For years, too, the spongy lenticels, which succeed the stomata and occur scattered over the external surface of the bark of trees and shrubs, serve to admit air to the interior of the stem. The lenticels at first appear as roundish spots, of very small size, but as the twig or shoot on which they occur increases in diameter the lenticel becomes spread out at right angles to the length of the stem, so that it sometimes becomes a long transverse slit or scar on the bark, as in the cherry and the birch. But in the trunk of a large tree no part of the bark except the inner layers is alive. The older portions of the bark, such as the highly developed cork of the cork-oak, from which the ordinary stoppers for bottles are made, sometimes cling for years after they are dead and useless, except as a protection for the parts beneath against mechanical injuries or against cold. But in many cases, as in the shellbark hickory and the grapevine, the old bark soon falls off in strips; in birches it finally peels off in bands around the stem.

The cambium layer is very much alive and so is the young outer portion of the wood. Testing this "sapwood," particularly in winter, shows that it is rich in starch and proteids.

The heartwood of a full-grown tree is hardly living, unless some of the medullary rays may retain their vitality, and so wood of this kind is useful to the tree mainly by the stiffness which it gives to the trunk and larger branches, thus preventing them from being easily broken by storms.

91. *Movement of Water in the Stem.* — The student has already learned (§ 50) that large quantities of water are taken up by the roots.

Having become somewhat acquainted with the structure of the stem, he is now in a position to investigate the question how the various fluids, commonly known as sap, travel about in it.[1] It is important to notice that sap is by no means the same substance everywhere and at all times. As it first makes its way by osmotic action inward through the root-hairs of the growing plant it differs but little from ordinary spring water or well water. The liquid which flows from the cut stem of a "bleeding" grapevine which has been pruned just before the buds have begun to burst in the spring, is water with a little mucilaginous or slimy material added. The sap which is obtained from maple trees in late winter or early spring, and is boiled down for syrup or sugar, is still richer in nutritious material than the water of the grapevine, while the elaborated sap which is sent so abundantly into the ear of corn, at its period of filling out, or into the growing pods of beans and peas, or into the rapidly forming acorn or the chestnut, contain great stores of food, suited to sustain plant or animal life.

92. ***Experiment 18.*** *Rise of Water in Exogenous Stems.* — Cut some short branches from a grapevine and stand the lower end of each in red ink; try the same experiment with twigs of oak, ash, or other porous wood, and after some hours examine with the magnifying glass and with the microscope, using the two-inch objective, successive cross-sections of one or more twigs of each kind. Note exactly the portions

[1] See the paper on *The so-called Sap of Trees and its Movements*, by Prof. Chas. R. Barnes, Science, XXI, 535.

through which the ink has traveled. Repeat with several potatoes, cut crosswise through the middle. For the sake of comparison between roots and stems, treat any convenient root, such as a parsnip, in the same way.

Examine longitudinal sections of some of the twigs, the potatoes, and the roots. In drawing conclusions about the channels through which the ink has risen (which are those through which the crude sap most readily travels), bear in mind the fact that a slow soakage of the red ink will take place in all directions, and therefore pay attention only to the strongly colored spots or lines.

What conclusions can be drawn from this experiment as to the course followed by the sap?

From the familiar facts that ordinary forest trees apparently flourish as well after the almost complete decay and removal of their heartwood, and that many kinds will live and grow for a considerable time after a ring of bark extending all round the trunk has been removed, it may readily be inferred that the crude sap in trees must rise through some portion of the newer layers of the wood.

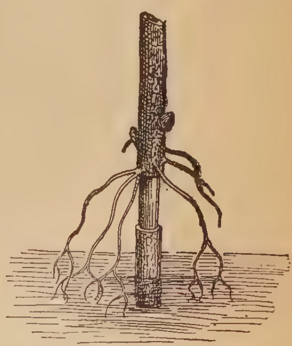


FIG. 55.—A Cutting Girdled and sending down Roots from the Upper Edge of the Girdled Ring.

Most dicotyledonous stems, when stripped of a ring of bark and then stood in water, as shown in Fig. 55, develop roots only at or near the upper edge of the stripped portion,[1] and this would seem to prove that such stems send their building-material — the elaborated sap — largely at any rate down through the bark. Its course is undoubtedly for the most part through the sieve-cells (Figs. 42–45), which are admirably adapted to convey liquids. In addition to these general upward and downward movements of

[1] This may be made the subject of a protracted class-room experiment. Strong shoots of willow should be used for the purpose.

sap there must be local transfers laterally through the stem, and these are at times of much importance to the plant.

93. *Rate of Movement of Water in the Stem.* — There are many practical difficulties in the way of ascertaining exactly how fast the watery sap travels from the root to the leaves. It is, however, easy to illustrate experimentally the fact that it does rise, and to give an approximate idea of the time required for its ascent. The best experiment for beginners is one which deals with an entire plant under natural conditions.

94. ***Experiment 19.*** *Wilting and Recovery.* — Allow a fuchsia or a hydrangea[1] which is growing in a flower-pot to wilt considerably for lack of watering. Then water it freely and record the time required for the leaves to begin to recover their natural appearance and position, and the time fully to recover.

The former interval of time will give a very rough idea of the time of transfer of water through the roots and the stem of the plant. From this, by measuring the approximate distance traveled, a calculation could be made of the number of inches per minute which water travels in this particular kind of plant, through a route which is partly roots, partly stem, and partly petiole. Still another method is to treat leafy stems as the student in Exp. 18 treated the twigs which he was examining, and note carefully the rate of ascent of the coloring liquid. This plan is likely to give results that are too low, still it is of some use. It has given results varying from 34 inches per hour for the willow to 880 inches per hour for the sunflower. A better method is to introduce the roots of the plant which is being experimented upon into a weak solution of some chemical substance which is harmless to the plant and which can readily be detected anywhere in the tissues of the plant by chemical tests. Proper tests are then applied to portions of the stem which are cut from the plant at short intervals of time.

[1] *Hydrangea hortensis.*

Compounds of the metal lithium are well adapted for use in this mode of experimentation.

95. *Causes of Movements of Water in the Stem.* — Some of the phenomena of osmose were explained in §§ 50–54, and the work of the root-hairs was described as due to osmotic action.

Root pressure (§ 55), being apparently able to sustain a column of water only 80 or 90 feet high at the most, and usually less than half this amount, would be quite insufficient to raise the sap to the tops of the tallest trees, since many kinds grow to a height of more than a hundred feet. Our Californian "big trees," or Sequoias, reach the height of over 300 feet, and an Australian species of Eucalyptus, it is said, sometimes towers up to 470 feet. Root pressure, then, may serve to start the soil-water on its upward journey, but some other force or forces must step in to carry it the rest of the way. What these other forces are is still a matter of discussion among botanists.

The slower inward and downward movement of the sap may be explained as due to osmose.

For instance, in the case of growing wood-cells, sugary sap from the leaves gives up part of its sugar to form the cellulose of which the wood-cells are being made.

This loss of sugar would cause a flow of rather watery sap to take place more rapidly than usual from the growing wood to the leaves, while at the same time a slow transfer of the dissolved sugar will be set up from leaves to wood. The water, as fast as it reaches the leaves, will be thrown off in the form of vapor, so that they will not become distended with water, while the sugar will be changed into cellulose and built into new wood-cells as fast as it reaches the region where such cells are being formed.

Plants in general[1] readily change starch to sugar, and sugar

[1] Not including most of the flowerless and very low and simple kinds.

to starch. When they are depositing starch in any part of the root or stem for future use, the withdrawal of sugar from those portions of the sap which contain it most abundantly gives rise to a slow movement of dissolved particles of sugar in the direction of the region where starch is being laid up.

96. *Storage of Food in the Stem.* — The reason why the plant may profit by laying up a food supply somewhere inside its tissues has already been suggested, § 70.

The most remarkable instance of storage of food in the stem is probably that of sago-palms, which contain an enormous amount, sometimes as much as 800 pounds, of starchy material in a single trunk. But the commoner plants of temperate regions furnish plenty of examples of deposits of food in the stem. As in the case of seeds and roots, starch constitutes one of the most important kinds of this reserve material of the stem, and since it is easier to detect than any other substance which the plant employs for this purpose, the student will do well to spend the time which he devotes to the study of storage of food in the stem to looking for starch only.

Cut thin cross-sections of twigs of any common hard-wood tree, in its winter condition, moisten with iodine solution, and examine for starch with a moderately high power of the microscope. Sketch the section, and describe exactly in what portions the starch is deposited.

97. *Storage in Underground Stems.* — The branches and trunk of a tree furnish the most convenient place in which to deposit nourishment during winter to begin the growth of the following spring. But in those plants which die down to the ground at the beginning of winter the storage must be either in the roots, as has been described in § 46, or in underground portions of the stem.

Rootstocks, tubers, and bulbs seem to have been developed by plants to answer as storehouses through the winter (or in

countries where there is one, through the dry season) for the reserve materials which the plant has accumulated during the growing season. The commonest tuber is the potato, and this fact and the points of interest which it represents make it especially desirable to use for a study of the underground stem in a form most highly specialized for the storage of starch and other valuable products.

98. *A Typical Tuber; the Potato.* — Sketch the general outline of a potato, showing the attachment to the stem from which it grew.[1]

Note the distribution of the "eyes," — are they opposite or alternate? Examine them closely with the magnifying glass and then with the lowest power of the microscope. What do they appear to be?

If the potato is a stem it may branch, — look over a lot of potatoes to try to find a branching specimen. If such a one is secured, sketch it.

Note the little scale overhanging the edge of the eye, and see if you can make out what this scale represents.

Cut the potato across, and notice the faint line which forms a sort of oval figure some distance inside the skin.

Place the cut surface in red ink, allow the potato to stand so for many hours, and then examine, by slicing off pieces parallel to the cut surface, to see how far and into what portions the red ink has penetrated. Refer to the notes on the study of the parsnip (§ 45), and see how far the behavior of the potato treated with red ink agrees with that of the parsnip so treated.

Cut a thin section at right angles to the skin, and examine with a high power. Moisten the section with iodine solution and examine again.

Make a cross-section and a lengthwise section through the stained ring from the piece left standing in red ink, and examine first with a low, then with a high power.

If possible secure a potato which has been sprouting in a warm place for a month or more (the longer the better), and look for evidences of the loss of material from the tuber.

99. ***Experiment 20.*** *Use of the Corky Layer.* — Carefully weigh a potato, then pare another larger one and cut portions from it until its weight is made approximately equal to that of the first one. Expose both freely to the air for some days and re-weigh. What does the result show in regard to the use of the corky layer of the skin?

[1] Examination of a lot of potatoes will usually discover specimens with an inch or more of attached stem.

100. *Morphology of the Potato.* — It is evident that in the potato we have to do with a very greatly modified form of stem. The corky layer of the bark is well represented, and the loose cellular layer beneath is very greatly developed; wood is almost lacking, being present only in the very narrow ring which was stained by the red ink, but the pith is greatly developed and constitutes the principal bulk of the tuber. All this is readily understood if we consider that the tuber, buried in and supported by the earth, does not need the kinds of tissue which give strength, but only those which are well adapted to store the requisite amount of nourishment.

101. *Structure of a Bulb; the Onion.*[1] — Examine the external appearance of the onion and observe the thin membranaceous skin which covers it. This skin consists of the broad sheathing bases of the outer leaves which grew on the onion plant during the summer. Remove these and notice the thick scales (also formed from bases of leaves as shown in Fig. 37) which make up the substance of the bulb.

Make a transverse section of the onion at about the middle and sketch the rings of which it is composed. Cut a thin section from the interior of the bulb, examine with a moderate power of the microscope, and note the thin-walled cells of which it is composed.

Split another onion from top to bottom and try to make out:

(*a*) The *plate* or broad flattened stem inside at the base, Fig. 36 *a*;

(*b*) The central bud;

(*c*) The bulb-scales;

(*d*) In some onions (particularly large, irregular ones) the bulblets or side buds arising in the axes of the scales near the base, Fig. 36 *b*.

Test the cut surface for starch.

Since the onion grows so rapidly on being planted in the spring there must be a large supply of nutritive material in the bulb. Much of this is in the form of *proteid* material. The proteids (§ 35) constitute a class of animal and vegetable substances, very valuable for food, of which the whites

[1] Probably a bulb with narrow scales like those of the lilies would be a more interesting form for study, but the onion is always and everywhere obtainable.

of eggs and the sticky part of dough made from wheat flour are good examples.

Nitric acid turns proteids yellow, and the addition of ammonia afterwards turns them deeper yellow or orange. As few other substances are affected in this way by nitric acid, this change of color is a very good test to show the presence of proteids.

102. ***Experiment 21.**** *Testing an Onion for Proteids.* — Test a rather thick slice of onion by heating it in a porcelain evaporating dish with a little strong nitric acid until the latter begins to boil and the onion becomes somewhat softened.[1] Rinse off the slice of onion in a stream of water, then pour on it a few drops of ammonia water and observe what changes of color (if any) occur.

Grape sugar is an important substance among those stored for food by the plant. It received its name from the fact that it was formerly obtained for chemical examination from grapes. Old dry raisins usually show little masses of whitish material scattered over the skin which are nearly pure grape sugar. Commercially it is now manufactured on an enormous scale from starch by boiling with diluted sulphuric acid. In the plant it is made from starch by processes as yet imperfectly understood, and another sugar, called *maltose*, is made from starch in the seed during germination.

Both grape sugar and maltose (and hardly any other substances) have the power of producing a yellow or orange color and throwing down an orange or reddish deposit, when they are added to a brilliant blue alkaline solution of copper, known as *Fehling's solution*.[2] The color or deposit will not appear until the solution has been heated to boiling.

[1] Do not allow the acid to touch the hands, the clothing, or any metallic object.

If it is desirable to show the result of the test to one or more classes, the portion of the onion stained yellow by the acid may be placed in a small wide-mouthed bottle with ground stopper, in which it may be kept for a long time and conveniently passed from hand to hand.

[2] For the preparation of the solution see Appendix B.

103. ***Experiment 22.*** *Testing for Grape Sugar.* — Heat to boiling in a test-tube or a small beaker some weak syrup of grape sugar or some honey, much diluted with water. Add Fehling's solution, a few drops at a time, until a decided orange color appears. Repeat the test with the water in which some slices of onion have been boiled, filtering the water through a paper filter and heating again to boiling before adding the test solution.[1]

Does the onion contain grape sugar?

[1] The deposit will in this case, even if orange at first, finally become black, probably owing to the presence of sulphur in the onion.

CHAPTER VIII.

Buds.

104. *Structure of Buds.* — While studying twigs in their winter condition, as directed in §§ 58, 59, the student had occasion to notice the presence, position, and arrangement of buds on the branch, but he was not called upon to look into the details of their structure. The most natural time to do this is just before the study of the leaf is begun, since, as every one knows, leaves spring from buds and the rudiments of leaves in some form must be found there.

105. *The Horse-Chestnut Bud.* — Examine one of the lateral buds on a twig in its winter or early spring condition.[1]

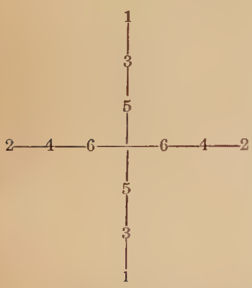
Make a sketch of the external appearance of the buds as seen with a magnifying glass.

The scales with which it is covered will be seen to overlap each other like shingles on a roof, and the thin edges of the scales fit very closely down over those beneath.

Notice the sticky coating on the scales.

Are the scales opposite or alternate ?

Remove the scales in pairs, placing them in order on a sheet of paper, thus :



Make the distance from 1 to 1 as much as 6 or 8 inches.

How many pairs are found ?

Observe as the scales are removed whether the sticky coating is thicker on the outside or the inside of each scale, and whether it is equally abundant on all the successive pairs.

What is the probable use of this coating ?

Note the delicate veining of some of the scales as seen through the magnifying glass.

[1] The best possible time for this examination is just as the buds are beginning to swell slightly in the spring. The buckeye will do for this examination, though it is on a good deal smaller scale than the horse-chestnut. Buds may be forced to open early by standing twigs in water in a very warm, light place.

Describe the texture, thickness, transparency, color, and so on, of each pair of scales.

Inside the innermost pair are found two forked woolly objects; what are these?

Compare with Fig. 75.

Their shape could be more readily made out if the woolly coating were removed.

Try the effect of immersing the inner portion of the bud for a few minutes in strong sulphuric acid to dissolve and remove the down, so as to show the parts more plainly.[1]

Can you suggest a use for the woolly coating?

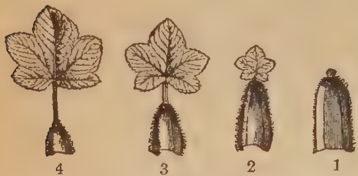


FIG. 56. — Transition from Bud-Scales to Leaves in the Common Currant.

Examine a terminal bud in the same way in which you have just studied the lateral bud.

Does it contain any parts not found in the other?

What is the appearance of these parts?

What do they represent?

If there is any doubt about their nature, study them further on a horse-chestnut tree during and immediately after the process of leafing out in the spring.

For comparison study at least one of the following kinds of buds in their winter or early spring condition: Hickory, butternut, beech, ash, magnolia (or tulip tree), lilac, balm of Gilead, cultivated cherry.[2]

106. *Nature of Bud-Scales.* — The fact that the bud-scales are in certain cases merely imperfectly developed leaves is often clearly manifest from the series of steps connecting the bud-scale on the one hand with the young leaf on the other, which may be found in many opening buds, as illustrated by Fig. 56. In other buds the scales are not imperfect leaves, but the little appendages (*stipules,* § 117) which occur at the

[1] The acid must not be allowed to get on the hands, the table, or the clothes, or it will cause much trouble. Remove it by rinsing in plenty of water.

[2] Consult the account of the mode of studying buds in Miss Newell's *Outlines*, Part I. If some of the buds are studied at home, pupils will have a better chance to examine at leisure the unfolding process.

bases of leaves. This kind of bud-scale is especially well shown in the magnolia and the tulip tree.

107. *Naked Buds.* — All of the buds above-mentioned are *winter buds*, capable of living through the colder months of the year, and are scaly buds.

In the herbs of temperate climates, and even in shrubs and trees of tropical regions, the buds are often *naked*, that is nearly or quite destitute of scaly coverings.

Make a study of the naked buds of any convenient herb, such as one of the common "geraniums" (pelargonium), and record what you find in it.

FIG. 57. — Alternate Leaves of Cultivated Cherry, with Buds in their Axils, in October.

108. *Position of Buds.* — The distinction between *lateral* and *terminal* buds has already been alluded to.

The plumule is the first terminal bud which the plant produces. Lateral buds are usually *axillary*, as shown in Fig. 57. But not infrequently there are several buds grouped in some way about a single leaf-axil, either one above the other, as in the black walnut, Fig. 58, or grouped side by side, as in the red maple and the cherry, Fig. 59.

In these cases all the buds except the axillary one are called *accessory* or *supernumerary* buds.

109. *Leaf-Buds and Flower-Buds; the Bud an Undeveloped Branch.* — Such buds as the student has so far examined for

himself are not large enough to show in the most obvious way the relation of the parts and their real nature.

Fortunately, it is easy to obtain a gigantic bud which illustrates perfectly the structure and arrangement of buds in general.

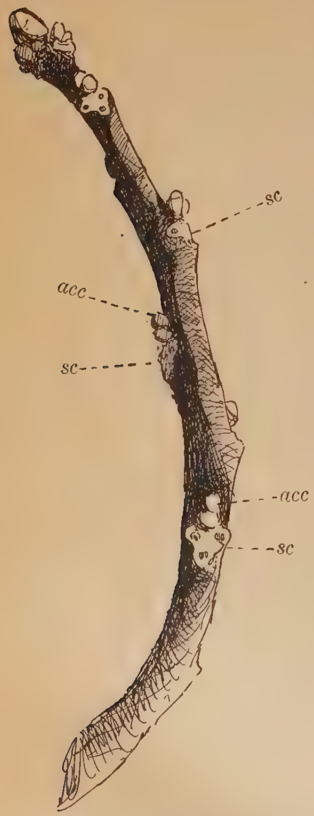


FIG. 58. — A Twig of Black Walnut.
sc, scar left by fallen leaf; just above this is an ordinary bud, and still higher up, *acc*, an accessory bud.

Examine and sketch a cabbage which has been split l e n g t h w i s e through the centre[1] and note

(*a*) The short, thick, conical stem.

(*b*) The crowded leaves which arise from the stem, the lower and outer ones largest and most mature, the upper and innermost ones the smallest of the series.

Compare the section of the cabbage with Fig. 60.

Most of the buds so far considered are *leaf-buds*, that is, their inner parts will develop into leaves, and their central axes into stems; but some were *mixed buds*, that is, they contained both leaves and flowers in an undeveloped condition.

Flower-buds contain the rudiments of flowers only.

Sometimes, as in the black walnut, the leaf-buds and flower-buds are readily distinguishable by their difference in form, while in other cases, as in the cultivated cherry, the difference in form is but slight.

[1] Half of a cabbage will be enough for the entire division.

The rings of scars about the twig, shown in Figs. 23 and 59, mark the place where the bases of bud-scales were attached. A little examination of the part of the twig which lies outside of this ring, as shown in Fig. 23, will lead one to the conclusion that this portion has all grown in the one spring and summer since the bud-scales of that particular ring dropped off. Following out this suggestion, it is easy to reckon the age of any moderately old portion of a branch, since it is equal to the number of segments between the rings. In rapidly growing shoots of willow, poplar, and similar trees, five or ten feet of the length may be the growth of a single year, while in the lateral twigs of the hickory, apple, or cherry the yearly increase may be but a fraction of an inch. Whatever the amount of this

FIG. 59. — A Slowly grown Twig of Cherry, three inches long and about ten years old.

The more pointed terminal bud is a leaf-bud, the more obtuse accessory buds, *acc*, are flower-buds.

FIG. 60. — I, a Twig of European Elm. II, a Longitudinal Section of the Buds of I, considerably magnified.

a, the axis of the bud, which will elongate into a shoot ; *b*, leaf-scars.

growth, it is but the lengthening out and development of the bud, which may be regarded as an undeveloped stem or branch, with its internodes so shortened that successive leaves seem almost to spring from the same point.

110. *Vernation.* — Procure a considerable number of buds which are just about to burst, and others which have begun to open. Cut each across with a razor or very sharp scalpel; examine first with the magnifying glass, and then with the lowest power of the microscope. Pick to pieces other buds of the same kinds under the magnifying glass, and report upon the manner in which the leaves are packed away.

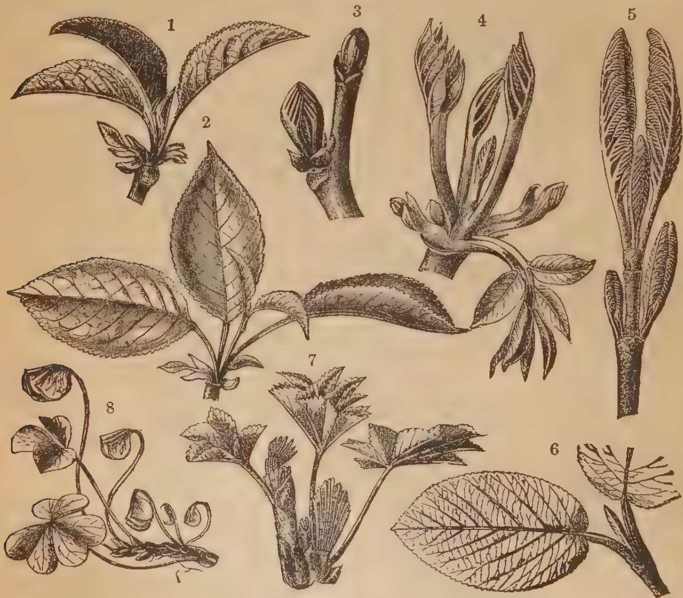


FIG. 61. — Types of Vernation.
1, 2, cherry; 3, 4, European walnut; 5, 6, snowball; 7, lady's-mantle; 8, wood sorrel.

The arrangement of leaves in the bud is called *vernation;* some of the principal modes are shown in Fig. 61. In the cherry the two halves of the leaf are folded together flat, with

the under surfaces outward; in the walnut the separate *leaflets*, or parts of the leaf, are folded flat and then grouped into a sort of cone; in the snowball each half of the leaf is plaited in a somewhat fan-like manner, and the edges of the two halves are then brought round so as to meet; in the lady's-mantle the fan-like plaiting is very distinct; in the wood sorrel each leaflet is folded smoothly, and then the three leaflets packed closely side by side. All these modes of vernation and many others have received accurate descriptive names by which they are known to botanists.

111. *Importance of Vernation.* — The significance of vernation is best understood by considering that there are two important purposes to be served; the leaves must be stowed as closely as possible in the bud, and upon beginning to open they must be protected from too great heat and dryness until they have reached a certain degree of firmness. It may be inferred from Fig. 61 that it is common for very young leaves to stand vertically. This protects them considerably from the scorching effect of the sun at the hottest part of the day. Many young leaves, as for instance those of the silver-leafed poplar, the pear, the beech, and the mountain ash, are sheltered and protected from the attacks of small insects by a coating of wool or down, which they afterwards lose. Those of the tulip tree are enclosed for a little time in a thin pouch, formed from the bud-scales,[1] and thus entirely shielded from direct contact with the outside air.

112. *Dormant Buds.* — Generally some of the buds on a branch remain undeveloped in the spring, when the other buds are beginning to grow, and this inactive condition may last for many seasons. Finally the bud may die, or some injury to the tree may destroy so many other buds as to leave the dormant ones an extra supply of nourishment, and this, with other causes, may force them to develop and to grow into branches.

[1] These are in this case stipules, § 117.

Sometimes the tree fails altogether to produce buds at places where they would regularly occur. In the lilac the terminal bud usually fails to appear, and the result is constant forking of the branches.

113. *Adventitious Buds.* — Buds which occur in irregular places, that is, not terminal nor in or near the axils of leaves, are called *adventitious buds;* they may spring from the roots, as in the silver-leafed poplar, or from the sides of the trunk, as in our American elm. In many trees, for instance willows and maples, they are sure to appear after the trees have been cut back. Willows are thus cut back or *pollarded,* as shown in Fig. 62, in order to cause them to produce a large crop of slender twigs suitable for basket-making.

FIG. 62. — Branches formed from Adventitious Buds on Pollarded Willows.

Leaves rarely produce buds, but a few kinds do so when they are injured; and those of the bryophyllum, a plant allied to the garden live-for-ever, almost always send out buds from the margin when they are removed from the plant while they are still green and fresh.

114. ***Experiment 23.*** — Pin up a bryophyllum leaf on the wall of the room or lay it on the surface of moist earth, and follow, day by day, the formation and development of the buds which it may produce.

This plant seems to rely largely upon leaf-budding to reproduce itself, for in a moderately cool climate it rarely flowers or seeds, but drops its living leaves freely, and from each such leaf one or several new plants may be produced.

CHAPTER IX.

Leaves.

115. *The Elm Leaf.* — Sketch the leafy twig of elm that is supplied to you.[1]

Report on the following points:

(*a*) How many rows of leaves?

(*b*) How much overlapping of leaves when the twig is held with the upper sides of the leaves toward you? Can you suggest a reason for

Fig. 63. — General Outline of Leaves.
a, linear; *b*, lanceolate; *c*, wedge-shaped; *d*, spatulate; *e*, ovate; *f*, obovate; *g*, kidney-shaped; *h*, orbicular; *i*, elliptical.

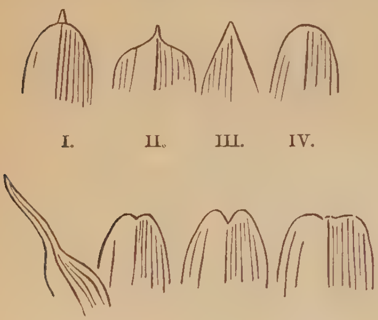
[1] Any elm will answer the purpose. Young strong shoots which extend horizontally are best, since in these leaves are most fully developed and their distribution along the twig appears most clearly. Other good kinds of leaves with which to begin the study, if elm leaves are not available, are those of beech, oak, willow, peach,

this? Are the spaces between the edges of the leaves large or small compared with the leaves themselves?

Pull off a single leaf and make a very careful sketch of its under surface, about natural size. Label the broad expanded part the *blade*, and the stalk by which it is attached to the twig, leaf-stalk or *petiole*.

Study the outline of the leaf and answer these questions:

(*a*) What is the shape of the leaf, taken as a whole? (See Fig. 63.) Is the leaf *bilaterally symmetrical*, *i.e.*, is there a middle line running



I. II. III. IV.

V. VI. VII. VIII.

FIG. 64. — Shapes of Tip of Leaf.

I, mucronate, the midrib prolonged into a hard short point; II, cuspidate, tapering into a stiff point; III, acute; IV, rounded;[1] V, acuminate or taper-pointed; VI, retuse, with the rounded end slightly notched; VII, emarginate, deeply notched; VIII, truncate, with the end cut off rather squarely.

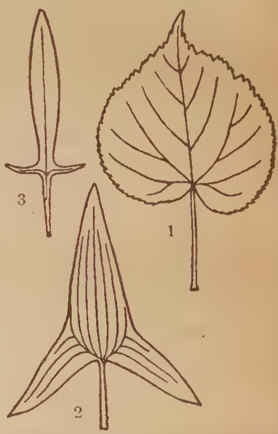


FIG. 65. — Shapes of Bases of Leaves.

1, heart-shaped (unsymmetrically); 2, arrow-shaped; 3, halberd-shaped.

through it lengthwise, along which it could be so folded that the two sides would precisely coincide?

(*b*) What is the shape of the tip of the leaf? (See Fig. 64.)

(*c*) Shape of the base of the leaf. (See Fig. 65.)

(*d*) Outline of the margin of the leaf? (See Fig. 66.)

cherry, apple. Most of the statements and directions above given would apply to any of the leaves just enumerated. If this chapter is reached too early in the season to admit of suitable material being procured for the study of leaf arrangement, that topic may be omitted until the leaves of forest trees have sufficiently matured.

[1] Any form intermediate between III and IV would be called obtuse.

Notice that the leaf is traversed lengthwise by a strong *midrib* and that many so-called *veins* run from this to the margin. Are these veins parallel? Hold the leaf up toward the light and see how the main veins are connected by smaller *veinlets*. Examine with your glass the leaf as held to the light and make a careful sketch of portions of one or two veins and the intersecting veinlets. How is the course of the veins shown on the upper surface of the leaf?

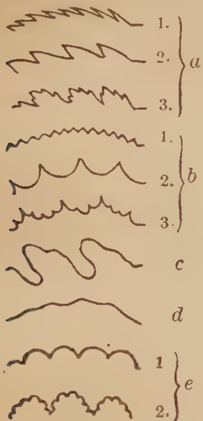


FIG. 66.—Shapes of Margins of Leaves. *a* (1), finely serrate; (2), coarsely serrate; (3), doubly serrate. *b* (1), finely dentate; (2), sinuate dentate; (3), doubly dentate. *c*, deeply sinuate. *d*. wavy. *e* (1), crenate or scalloped; (2), doubly crenate.

FIG. 67.—Netted Veining (pinnate) in the Leaf of the Foxglove.

Examine both surfaces of the leaf with the glass and look for hairs distributed on the surfaces. Describe the manner in which the hairs are arranged.

The various forms of leaves are classed and described by botanists with great minuteness,[1] not simply for the study of

[1] See Kerner and Oliver's *Natural History of Plants*, vol. I, pp. 623–637.

leaves themselves, but also because in classifying and describing plants the characteristic forms of the leaves of many kinds of plants form a very simple and ready means of distinguishing them from each other and identifying them. The student is not expected to learn the names of the several shapes of leaves as a whole or of their bases, tips, or margins, except in those cases in which he needs to use and apply them.

116. *The Maple Leaf.*[1] — Sketch the leafy twig.

Are the leaves arranged in rows like those of the elm? How are they arranged?

FIG. 68. — Palmately Netted-Veined Leaf of Melon.

FIG. 69. — Pinnately Divided Leaf of Celandine.

The blade of the leaf is discontinuous, consisting of several portions between which are spaces in which no part of the blade has been developed.

Notice the way in which half of the whole number of petioles are twisted and some of the others bent to bring the proper surface of the leaf upward toward the light.

Do the edges of these leaves show larger spaces between them than the elm leaves did, *i.e.*, would a spray of maple intercept the sunlight

[1] Any kind of maple will answer the purpose. Palmately veined leaves are less abundant among our forest trees than are pinnately veined ones. The sycamore is one of the commonest species. Among other plants may be suggested the ordinary "geraniums" (pelargoniums), the pumpkin, squash, grape, currant, and hollyhock.

more or less perfectly than a spray of elm? Pull off a single leaf and sketch its lower surface, about natural size.

Of the two main parts whose names have already been learned (blade and petiole), which is more developed in the maple than in the elm leaf?

Describe:

(*a*) The shape of the maple leaf as a whole.

(*b*) Its outline as to main divisions, of what kind and how many.

(*c*) The detailed outline of the margin (Fig. 66).

Compare the mode of veining or venation of the elm and the maple leaf by making a diagram of each.

FIG. 70. — Palmately Divided Leaf of Buttercup.

FIG. 71. — Leaf of Apple, with Stipules.

FIG. 72.—Leaf of Pansy, with Leaf-like Stipules.

They agree in being *netted-veined*, *i.e.*, in having veinlets that join each other at many angles so as to form a sort of delicate lace-work like Figs. 67, 68.

They differ, however, in the arrangement of the principal veins. Such a leaf as that of the elm is said to be feather-veined, or *pinnately veined.*

The maple leaf, or any leaf with closely similar venation, is said to be *palmately veined.* Describe the difference between the two plans.

117. *Stipules.* — Although they are absent from many leaves, and disappear early from others, *stipules* form a part of what the botanist regards as an ideal or model leaf.[1] When present they are sometimes found as little bristle-shaped objects, at the base of the leaf as in the apple leaf (Fig. 71), sometimes as leaf-like bodies, for example in the pansy (Fig. 72), and in many other forms, one of which is that of spinous appendages, as shown in the common locust (Fig. 76).

118. *Relation of Venation to Shape of Leaves.* — As soon as the student begins to observe leaves somewhat widely, he can hardly fail to notice that there is a general relation between the plan of venation and the shape of the leaf. How may this relation be stated? In most cases the principal veins follow at the outset a pretty straight course, a fact for which the student ought to be able to give a reason after he has performed Exp. 25.

FIG. 73. — Parallel-Veined Leaf of Solomon's Seal.

On the whole the arrangement of the veins seems to be such as to stiffen the leaf most in the parts that need most support, and to reach the region near the margin by as short a course as possible from the end of the petiole.

119. *Parallel-Veined Leaves.* — The leaves of many great groups of plants, such as the lilies, the sedges, and the grasses, are commonly *parallel-veined*, that is, with the veins running nearly parallel, lengthwise through the blade, as shown in Fig. 73, or with parallel veins proceeding from a midrib and then sending off parallel veinlets, as shown in Fig. 74.

[1] Unless the elm twigs used in the previous study were cut soon after the unfolding of the leaves in spring, the stipules may not have been left in any recognizable shape.

120. *Occurrence of Netted Veining and of Parallel Veining.* —The student has already, in his experiments on germination, had an opportunity to observe the difference in mode of veining between the leaves of some dicotyledonous plants and those of monocotyledonous plants. This difference is general throughout these great groups of flowering plants. What is the difference?

The polycotyledonous pines, spruces, and other coniferous trees have leaves with but a single vein, or two or three parallel ones, but in their case the veining could hardly be other than parallel, since the needle-like leaves are so narrow that no veins of any considerable length could exist except in a position lengthwise of the leaf.

FIG. 74. — Parallel Veining in Canna. Veins running from midrib to margin.

The fact that a certain plan of venation is found mainly in plants with a particular mode of germination, of stem structure, and of arrangement of floral parts, is but one of the frequent cases in botany in which the structures of plants are correlated in a way which it is not easy to explain.

No one knows why plants with two cotyledons should have netted-veined leaves, but many such facts as this are familiar to every botanist.

121. *Simple and Compound Leaves.* — The leaves so far studied are *simple leaves,* that is, leaves of which the blades are more or less entirely united into one piece. But while in the elm the margin is cut in only a little way, in some maples it is deeply cut in toward the bases of the veins. In some leaves the gaps between the adjacent portions extend all the way down to the petiole (in palmately veined leaves) or to

the midrib (in pinnately veined ones). Such divided leaves are shown in Figs. 69 and 70.

In still other leaves, known as *compound leaves*, the petiole, as shown in Fig. 75, or the midrib, as shown in Fig. 76, bears what look to be separate leaves. These differ in their nature and mode of origin from the portions of the blade of a divided leaf. One result of this difference appears in the fact

FIG. 75. — The Fall of the Horse-Chestnut Leaf.

that some time before the whole leaf is ready to fall from the tree or other plant in autumn, the separate portions or leaflets of a compound leaf are seen to be jointed at their attachments, just as whole leaves are to the part of the stem from which they grow. In Fig. 75 the horse-chestnut leaf is shown at the time of falling, with some of the leaflets already disjointed.

That a compound leaf, in spite of the joints of the separate leaflets, is really only one leaf, is shown : (1) by the absence of buds in the axils of leaflets ; (2) by the arrangement of the blades of the leaflets horizontally, without any twist in their individual leafstalks ; (3) by the fact that their arrangement

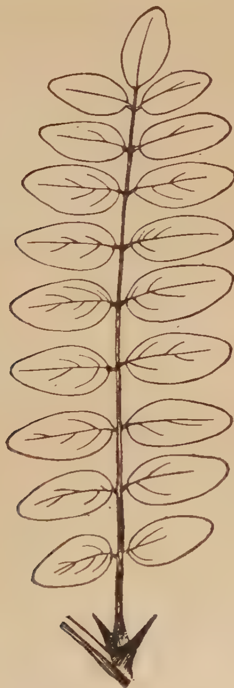


FIG. 76. — Pinnately Compound Leaf of Locust, with Spines for Stipules.

on the midrib does not follow any of the systems of leaf arrangement on the stem (§ 122). If each leaflet of a compound leaf should itself become compound, the result would be to produce a *twice compound* leaf. Fig. 85 shows that of an acacia.

CHAPTER X.

Leaf Arrangement for Exposure to Sun and Air; Movements of Leaves and Shoots.

122. *Leaf Arrangement.*[1] — As has been learned from the study of the leafy twigs examined, leaves are quite generally arranged so as to secure the best possible exposure to the sun and air. This,

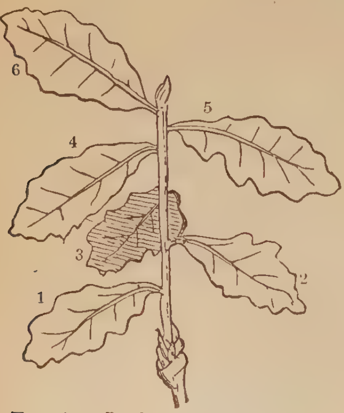


FIG. 77. — Leaf Arrangement of the Oak.


FIG. 78. — Leaf Arrangement of European Beech.

in the vertical shoots of the elm, the oak (Fig. 77), the apple, beech, and other alternate-leaved trees, is not inconsistent with their spiral arrangement of the leaves around the stem. In horizontal twigs and branches of the elm, the beech (Fig. 78), the chestnut, the linden, and many other trees and shrubs, the desired effect is secured by the arrangement of all the leaves in two flat rows, one on each side of the twig. The rows are produced, as it is easy to see on examining such a

[1] See Kerner and Oliver's *Natural History of Plants*, vol. I, pp. 396-424

leafy twig, by a twisting about of the petioles. The adjustment in the syringa, the maple, the horse-chestnut (Fig. 79),

FIG. 79. — Leaf Arrangement of Horse-Chestnut on Vertical Shoots (top view).

FIG. 80. — Leaf Arrangement of Horse-Chestnut on Vertical Shoots (side view).

and many other opposite-leaved trees and shrubs, consists in having each pair of leaves cover the spaces between the

pair below it, and sometimes in the lengthening of the lower petioles so as to bring the blades of the lower leaves outside those of the upper leaves. Examination of Fig. 80 will make the matter clear.

The student should not fail to study the leafage of several trees of different kinds on the growing tree itself, and to

FIG. 81. — Opposite Leaves of Deutzia[1] (from the same shrub as Fig. 82), as arranged on horizontal branch.

notice how circumstances modify the position of the leaves. Maple leaves, for example, on the ends of the branches are arranged much like those of the horse-chestnut, but they are found to be arranged more nearly flatwise along the inner portions of the branches, that is, the portions nearer the tree.

[1] *Deutzia crenata.*

Figs. 81 and 82 show the remarkable difference in arrangement in different branches of the Deutzia, and equally interesting

FIG. 82. — Opposite Leaves of Deutzia, as arranged on a vertical branch.

FIG. 83. — Leaves of Castor-Oil Plant, seen from above, showing exposure to sunlight. (Much reduced.)

modifications may be found in alternate-leaved trees, such as the elm and the cherry.

Where the stem on which the leaves are borne stands neither horizontally nor vertically, but at some oblique angle to the earth's surface, the leaf arrangement is more or less irregular, as in Fig. 83, which represents the leafage of a castor-oil plant growing in an inclined position, because it was shaded on one side.

123. *Daily Movements of Leaves.* — Many compound leaves have the power of changing the position of their leaflets to accommodate themselves to varying conditions of light and temperature. The so-called "sleep" of plants has long been known, but this subject has been most carefully studied rather recently. The wood sorrel, or oxalis, the common bean, clovers, and the locust tree are some of the most familiar of the plants whose leaves assume decidedly different positions at night from those which they occupy during the day. Sometimes the leaflets rise at night, and in many instances they droop, as in the white clover, Fig. 84, and the acacia, Fig. 85. One useful purpose, at any rate, that is served by the leaf's taking the nocturnal position is protection from frost. It has been proved experimentally that when part of the leaves on a plant are prevented from assuming the folded position, while others are allowed to do so, and the plant is then exposed during a frosty night, the folded ones may escape while the others are killed. The student may very naturally inquire whether the change to the nocturnal position is brought about by the change from light to darkness or whether it depends rather upon the time of day. It will be interesting to try an experiment in regard to this.

FIG. 84. — A Leaf of White Clover.
A, leaf by day; *B*, the same leaf asleep at night.

124. ***Experiment 24.*** — Remove a pot containing an oxalis from a sunny window to a dark closet, and note at intervals of five minutes the condition of its leaves for half an hour or less.

Some plants have the power of directing the leaves edgewise towards the sun during the hottest parts of the day, allowing them to extend their surfaces more nearly in a horizontal direction during the cooler hours.

FIG. 85. — A Leaf of Acacia.
A, as seen by day; *B*, the same leaf asleep at night.

125. *Vertically Placed Leaves.* — Very many leaves, like those of the iris, Fig. 34, always keep their principal surfaces nearly vertical, thus receiving the morning and evening sun upon their faces, and the noonday sun (which is so intense as to injure them when received full on the surface) upon their edges. This adjustment is most perfect in the compass-plant of the prairies of the Mississippi basin. Its leaves stand very

nearly upright, with their edges approximately north and south, Fig. 86, so that the rays of the midsummer sun will during every bright day first strike the leaf-surfaces at right

FIG. 86. — Leaves standing nearly Vertical in Compass-Plant (*Silphium laciniatum*).

angles, then be nearly parallel to them, and again toward sunset strike them at right angles.

126. *Movements of Leaves and Stems toward Light.* — The student doubtless learned from his experiments with seedling

plants that they tend to seek the light. The whole plant usually bends toward the quarter from which the strongest light comes, and the petioles bend with it. Such movements may produce very perceptible changes in the course of a few hours. If the position of the plant is shifted after the mature portions have taken a permanent bend, the youngest

FIG. 87.—Shoots of Dwarf Tropæolum, showing bending of young shoots toward sunlight.

The older portions of the shoots have bent to the left, away from the light (as climbing plants usually do), and toward a close fence. The younger tips of the shoots have bent to the right, the direction from which most light was received.

portions may be made to bend in the opposite direction, as shown in Fig. 87, and a third bending may then be produced, giving the longer shoots the form of the capital letter S.

It is not easy to explain in detail how the tissues of the plant act in producing these movements.

CHAPTER XI.

Leaves of Peculiar Forms and Uses.

127. *Leaves in Hot, Dry Climates.* — In regions where the greatest dangers to vegetation arise from long droughts and the excessive heat of the sun, the leaves of plants usually offer much less surface to the sun and air than is the case in temperate climates. Sometimes the blade disappears and the

FIG. 88. — Leaf of Nightshade,[1] with Midrib Prickly above and below.

FIG. 89. — Spiny Leaves of Barberry.

expanded petiole answers the purpose of a blade, or again, foliage leaves disappear altogether, as in the cactuses (Fig. 38) and the euphorbias (Fig. 90), and the green outer layers of the stem do the work of the leaves.

[1] *Solanum*

128. *Prickly Leaves.* — In many whole groups of plants the leaves are sufficiently prickly or spiny to serve the plant as a protection against browsing animals. Oftentimes the prickles are borne on the midrib or the principal veins only, as in some kinds of nightshade (Fig. 88). At other times the tip of the midrib, or the tips of that and other veins become spiny, as in the thistle. In many acacias, and in some euphor-

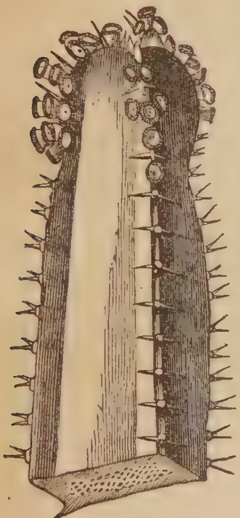


FIG. 90. — Branch of a Euphorbia, with Spiny Stipules.

FIG. 91. — Compound Leaf of Pea,[1] the leaflets at the upper end in the form and doing the work of tendrils.

bias (Fig. 90), the stipules form slender spines. Sometimes, in the barberry, for example, whole leaves become narrowed and hardened into spines. (Fig. 89.)

129. *Leaves as Aids to Climbing.* — Some pinnately compound leaves, like those of the pea, terminate in a tendril

[1] In young seedlings, as the student has already learned during the germination experiments, only one pair of leaflets will be found.

(Fig. 90), by means of which the plant is enabled to climb. Occasionally a tendril takes the place of the whole leaf, and again tendrils occupy the place of stipules. The long petioles of some leaves aid the plant to climb by twining themselves about any convenient support, as is the case with the common "nasturtium" (Tropæolum), Fig. 31.

130. *Leaves as Insect Traps.* — In the ordinary pitcher plants (Fig. 92), the leaf appears in the shape of a more or

FIG. 92. — Common Pitcher Plant.[1] At the right one of the pitcher-like leaves is shown in cross-section.

FIG. 93. — A Leaf of Sundew.[2] (Slightly magnified.)

less hooded pitcher. These pitchers are usually partly filled with water, and in this water very many drowned and decaying insects are commonly to be found. The insects have flown or crawled into the pitcher, and, once inside, have been unable to escape on account of the dense growth of bristly hairs about the mouth, all pointing inward and downward.

[1] *Sarracenia purpurea.* [2] *Drosera rotundifolia.*

How much the common American pitcher plants depend for nourishment on the drowned insects in the pitchers is not definitely known, but it is certain that some of the tropical species require such food.[1]

In other rather common plants, the sundews, insects are caught by a sticky secretion which proceeds from hairs on the leaves. In one of the commonest sundews the leaves consist of a roundish blade, borne on a moderately long petiole. On the inner surface and round the margin of the blade (Fig. 93) are borne a considerable number of short bristles, each terminating in a knob which is covered with a clear, sticky liquid. When a small insect touches one of the sticky knobs, he is held fast and the hairs at once begin to close over him, as shown in Fig. 94. Here he soon dies and then usually remains for many days, while the leaf pours out a juice by which the soluble parts of the insect are digested. The liquid containing the digested portions is then absorbed by the leaf and contributes an important part of the nourishment of the plant, while the undigested fragments, such as legs, wing-cases, and so on remain on the surface of the leaf or may drop off after the hairs let go their hold on the captive insect.

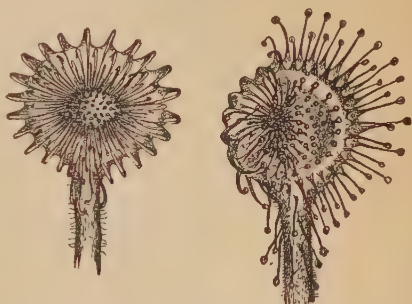


FIG. 94. — Leaves of Sundew. (Slightly magnified.)

The one at the left has all its tentacles closed over captured prey; the one at the right has only half of them thus closed.

[1] Where the *Sarracenia* is abundant it will be found interesting and profitable to make a careful class study of its leaves. See Geddes, *Chapters in Modern Botany*, Chapters I and II.

In the Venus' flytrap, which grows in the sandy regions of eastern North Carolina, the mechanism for catching insects is still more remarkable. The leaves, as shown in Fig. 95, terminate in a hinged portion which is surrounded by a fringe of stiff bristles. On the inside of each half of the trap grow three short hairs. The trap is so sensitive that when these hairs are touched it closes with a jerk and very generally succeeds in capturing the fly or other insect which has sprung it. The imprisoned insect then dies and is digested, somewhat as in the case of those caught by the sundew, after which the trap reopens and is ready for fresh captures.

FIG. 95. — Venus' Flytrap.

131. *Object of Catching Animal Food.* — It is easy to understand why a good many kinds of plants have taken to catching insects, or even (in the case of some of the large tropical pitcher plants) to catching birds, killing them, digesting them, and absorbing the digested products. Carnivorous, or flesh-eating, plants belong usually to one of two classes as regards their place of growth: they are bog-plants or air-plants. In either case their roots find it difficult to secure much nitrogen-containing food, that is, much food out of which proteid material can be built up. Animal food, being itself largely proteid, is admirably adapted to nourish the growing parts of

plants, and those which could develop insect-catching powers would stand a far better chance to exist as air-plants or in the thin, watery soil of bogs than plants which had acquired no such resources.

132. *Leaf Disguises.*—Leaves in the form of spines, of tendrils, and of pitchers have been referred to, and it is not uncommon to find leaves in other forms, hardly recognizable, except by the botanist, as leaves. The student has learned to consider bud-scales and the scales on root-stocks and bulbs as leaves (§§ 101, 106). Storage-leaves above ground are common in desert regions and not very unusual in plants of temperate climates. The common century plant is an excellent example of food-storage in the leaf, and the aloes, echeverias and house-leeks are other instances. There is little difficulty in recognizing dwarfed leaves in the little bracts which occur in many kinds of flower-cluster (Fig. 105). Scale-like leaves are found on some stems above ground, as in the case of the curious Indian pipe (Fig. 100), and on young shoots of asparagus in early spring. Leaves forming the parts of the flower will be studied in a later chapter (XVI). The leaf sometimes, though rarely, appears as a wing to aid in the transportation of the fruit, as in the linden (Fig. 173).

CHAPTER XII.

Minute Structure of Leaves; Functions of Leaves.

133. *Leaf of Lily.* — A good kind of leaf with which to begin the study of the microscopical structure of leaves in general is that of the lily.[1]

134. *Cross-Section of Lily Leaf.* — The student should first examine with the microscope a cross-section of the leaf, that is, a very thin slice, taken at right angles to the upper and under surfaces and to the veins. This will evidently show:

(*a*) The upper epidermis of the leaf.

(*b*) The intermediate tissues.

(*c*) The lower epidermis.

Use a power of from 100 to 200 diameters. In order to make out the relations of the parts, and to get their names, consult Fig. 96. Your section is by no means exactly like the figure. Label properly all the parts shown in your sketch.

Are any differences noticeable between the upper and the lower epidermis? Between the layers of cells immediately adjacent to each?

The teacher can (after considerable practice) prepare such sections by doubling the leaf crosswise once or twice, and then slicing the required sections from the end of the folded leaf, held firmly in the hand, if necessary between bits of elder-pith to hold it in position. The razor must be sharp, and the stroke made rather quickly and long.[2] The upper edge of a section may be distinguished from the under one by the presence in the former of *palisade* cells, so called from their resemblance to the high fence known as a palisade, made of stout stakes driven into the ground, Fig. 96. Mount in glycerine for temporary use in class.

135. *Under Surface of Lily Leaf.* — Examine with a power of 200 or more diameters the outer surface of a piece of epidermis from the lower side of the leaf.[3] Sketch carefully, comparing your sketch with Figs. 97 and 98, and labeling it to agree with those figures.

[1] Any kind of lily will answer.

[2] Consult Clark's *Practical Methods in Microscopy*, pp. 67–70.

[3] The epidermis may be started with a sharp knife, then peeled off with small forceps, and mounted in water for microscopical examination.

Examine another slice from the upper surface.

How does the number of *stomata* in the two cases compare?

Take measurements from the last three sketches with a scale and, knowing what magnifying power was used, answer these questions:[1]

(*a*) How thick is the epidermis?

(*b*) What is the length and the breadth of the epidermal cells?

(*c*) What is the average size of the pulp-cells?

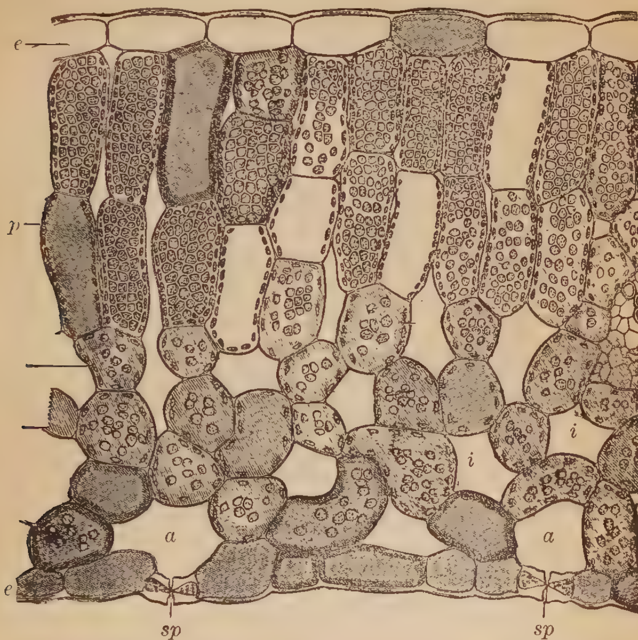


FIG. 96. — Vertical Section of the Leaf of the Beet. (Much magnified.)

e, epidermis; *p*, palisade cells (and similar elongated cells); *i*, intercellular spaces; *a*, air-spaces communicating with the stomata; *sp*, stomata, or breathing-pores.

136. *Uses of the Parts Examined.* — It will be most convenient to discuss the uses of the parts of the leaf a little

[1] The teacher may measure the size with the *camera lucida*.

later, but it will make matters simpler to state at once that the epidermis serves as a mechanical protection to the parts beneath and prevents excessive evaporation, that the palisade cells (which it may not be easy to make out very clearly in a roughly prepared section) help to prevent too rapid evaporation of sap from the leaf when exposed to excessive dryness, heat, and direct sunlight, and that they hold large quantities of the green coloring-matter of the leaf in a position where it

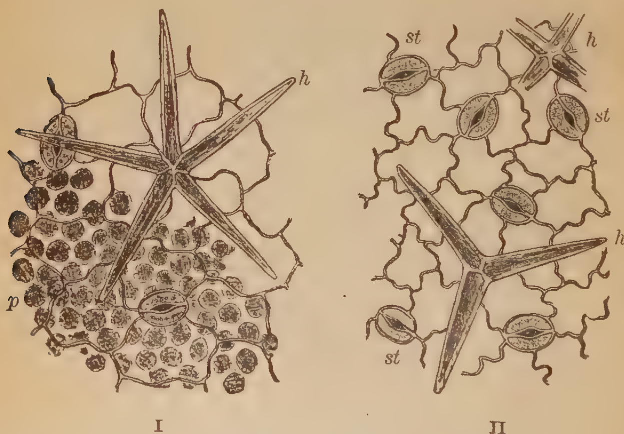


FIG. 97. — Epidermis of Leaf of Althæa. (Much magnified.)
I, from upper surface; II, from lower surface; *h*, star-shaped compound hairs; *st*, stomata; *p*, upper ends of palisade cells, seen through the epidermis.

can receive enough, but not too much sunlight. The stomata admit air to the interior of the leaf (where the air-spaces serve to store and to distribute it) and, above all, they regulate the evaporation of water from the plant.

137. *Leaf of "India-Rubber Plant."*[1] — Study with the microscope, as the lily leaf was studied, make the same set of sketches, note the differences in structure between the two leaves, and try to make out their meaning.

[1] *Ficus elastica.*

How does the epidermis of the two leaves compare?
Which has the larger stomata?
Which would better withstand great heat and long drought?

138. *Chlorophyll as found in the Leaf.* — Slice off a little of the epidermis from some such soft, pulpy leaf as that of the common field sorrel,[1] live-forever, or spinach; scrape from the exposed portion a very little of the green pulp; examine with the highest power attainable with your microscope, and sketch several cells.

Notice that the green coloring matter is not uniformly distributed, but that it is collected into little particles called *chlorophyll bodies* (Figs. 96, 98) and 205, *e*.

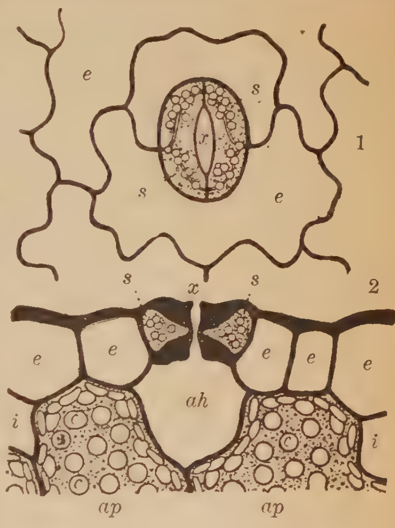


FIG. 98. — A Stoma of Thyme.

1, Surface view; *2*, Section; *e*, epidermal cells; *s*, guard-cells; *x*, stoma; *ah*, air-chamber; *ap*, pulp-cells of the leaf with chlorophyll bodies, *c*; *i*, intercellular air-spaces. (Both greatly magnified.)

139. *Woody Tissue in Leaves.* — The veins of leaves consist of fibro-vascular bundles containing wood and vessels much like those of the stem of the plant. Indeed, these bundles in the leaf are continuous with those of the stem, and consist merely of portions of the latter, looking as if unraveled, which pass outward and upward from the stem into the leaf under the name of *leaf-traces*. These traverse the petiole often in a somewhat irregular fashion. It is now easy to see that the dots noted on the leaf-scars of the horse-

[1] *Rumex acetosella.*

chestnut, Fig. 75, the black walnut, Fig. 58, and other trees, are merely the spots at which the leaf-traces passed from stem to petiole.

Experimental Study of Functions of Leaves. — The most interesting and profitable way in which to find out what work leaves do for the plant is by experimenting upon them. Much that relates to the uses of leaves is not readily shown in ordinary class-room experiments, but some things can readily be demonstrated in the experiments which follow.

140. ***Experiment 25.*** *Transpiration.* — Take two twigs or leafy shoots of any thin-leafed plant;[1] cover the cut end of each stem with a bit of grafting wax[2] to prevent evaporation from the cut surface. Put one shoot into a fruit jar, and leave in a warm room; screw the top on, put the other beside it, and allow both to remain some hours. Examine the relative appearance of the two, as regards wilting, at the end of the time.

Which shoot has lost most? Why? Has the one in the fruit jar lost any water? To answer this question, put the jar (without opening it) into a refrigerator; or, if the weather is cold, out of doors for a few minutes, and examine the appearance of the inside of the jar. What does this show?[3]

141. *Uses of the Epidermis.*[4] — The epidermis, by its toughness, tends to prevent mechanical injuries to the leaf, while by the transformation of a portion of its outer portion into a corky substance it greatly diminishes the loss of water from the general surface. In most cases, as in the india-rubber tree, the epidermal cells (and often two or three layers of cells beneath these) are filled with water, and thus serve as reservoirs from which the outer parts of the leaf and the stem are at times supplied.

In many cases, noticeably in the cabbage, the epidermis is

[1] Hydrangea, squash, melon or cucumber is best; many other kinds will answer very well.

[2] Grafting wax may be bought of nursery men or seedsmen.

[3] If the student is in doubt whether the jar filled with ordinary air might not behave in the same way, the question may be readily answered by putting a sealed jar of air into the refrigerator.

[4] See Kerner and Oliver's *Natural History of Plants*, vol. I, pp. 273-362.

covered with a waxy coating, which doubtless increases the power of the leaf to retain needed moisture, and which certainly prevents rain or dew from covering the leaf-surfaces, especially the lower surfaces, so as to prevent the operation of the stomata. Many common plants, like the meadow rue and the nasturtium, possess this power to shed water to such a degree that the under surface of the leaf is hardly wet at all when immersed in water, and the air-bubbles on the leaves give them a silvery appearance when held under water.

142. *Hairs on Leaves.* — Many kinds of leaves are more or less hairy or downy, as those of the mullein, the "mullein pink," many cinquefoils, and other common plants. In some instances this hairiness may be a protection against snails or other small leaf-eating animals, but in other cases it seems to be pretty clear that the woolliness (so often confined to the under surface) is to lessen the loss of water through the stomata. The Labrador tea is an excellent example of a plant, with a densely woolly coating on the lower surface of the leaf. The leaves, too, are partly rolled up, with the upper surface outward, so as to give the lower surface a sort of deeply-grooved form, and on this lower surface all of the stomata are placed. This plant, like some others with the same characteristics, ranges far north into regions where the temperature, even during summer, often falls so low that absorption of water by the roots ceases, since it has been shown that this stops a little above the freezing point of water. Exposed to cold, dry winds, the plant would then often be killed by complete drying up if it were not for the protection afforded by the woolly, channeled under surfaces of the leaves.[1]

143. *Operation of the Stomata.* — The stomata serve to admit air to the interior of the leaf, and to allow moisture, in the form of vapor, to pass out of it. They do this not in a

[1] This adaptation is sufficiently interesting for class study.

passive way, as so many mere holes in the epidermis might, but to some extent they regulate the rapidity of transpiration, opening more widely in damp weather and closing in dry weather. The opening is produced by each of the guard-cells bending into a more kidney-like form than usual, and the closing by a straightening out of the guard-cells. The under side of the leaf, free from palisade cells and abounding in intercellular spaces, is especially adapted for the working of the stomata, and accordingly we find them in much greater numbers on the lower than the upper surface. On the other hand, the little flowerless plants known as liverworts, which lie prostrate on the ground, have their stomata on the upper surface, and so do the leaves of pond lilies, which lie flat on the water. In those leaves which stand with their edges nearly vertical, the stomata are distributed somewhat equally on both surfaces. Stomata occur on the epidermis of young stems, being replaced later by the lenticels. Those plants which, like the cacti, have no ordinary leaves, transpire through the stomata scattered over their general surfaces.

The health of the plant depends largely on the working and proper condition of the stomata, and one reason why plants in cities often fail to thrive is that the stomata become choked with dust and soot. In some plants, as the oleander, provision is made for the exclusion of dust by a fringe of hairs about the opening of each stoma. If the stomata were to become filled with water, their activity would cease until they were freed from it; hence many plants have their leaves, especially the under surfaces, protected by a coating of wax which sheds water.

144. ***Experiment 26.**** *Amount of Water lost by Transpiration.* — Procure a thrifty hydrangea[1] and a small "india-rubber plant,"[2] each growing in a small flower-pot, and with the number of square inches

[1] The common species of the greenhouses, *Hydrangea hortensis.*
[2] This is really a fig, *Ficus elastica.*

of leaf-surface in the two plants not too widely different. Calculate the area of the leaf-surface for each plant, by dividing the surface of a piece of tracing cloth into a series of squares one-half inch on a side, holding an average leaf of each plant against this and counting the number of squares and parts of squares covered by the leaf. This area, multiplied by the number of leaves for each plant, will give approximately the total evaporating surface for each.

Transfer each plant to a glass battery jar of suitable size. Cover the jar with a piece of sheet lead, slit to admit the stem of the plant, invert the jar and seal the lead to the glass with a hot mixture of beeswax and rosin. Seal up the slit and the opening about the stem with grafting wax. A thistle-tube, such as is used by chemists, is also to be inserted, as shown in Fig. 99.[1] The mouth of this should be kept corked when the tube is not in use for watering.

FIG. 99. — A Hydrangea for Exp. 26.

Water each plant moderately and weigh them separately on a balance that is sensitive to one or two grams. Record the weights, allow the plants to stand in a sunny, warm room for 24 hours and reweigh.

Add to each plant just the amount of water which is lost,[2] and continue the experiment in the same manner for several days so as to ascertain, if possible, the effect upon transpiration of varying amounts of water in the atmosphere.

Calculate the average loss per 100 square inches of leaf-surface for each plant throughout the whole course of the experiment. Divide the greater loss by the lesser to find their ratio. Find the ratio of each plant's greatest loss per day to its least loss per day, and by comparing these ratios decide which transpires more regularly.

[1] It will be much more convenient to tie the hydrangea if one has been chosen that has but a single main stem. Instead of the hydrangea the common cineraria, *Senecio cruentus*, does very well.

[2] The addition of known amounts of water may be made most conveniently by measuring it in a cylindrical graduate.

Try the effect of supplying very little water to each, so that the hydrangea will begin to droop, and see whether this changes the relative amount of transpiration for the two plants. Vary the conditions of the experiment for a day or two as regards temperature, and again for a day or two as regards light, and note the effect upon the amount of transpiration.[1]

The structure of the fig leaf has already been studied. That of the hydrangea is looser in texture and more like the leaf of the lily or the beet, Fig. 96.

What light does the structure throw on the results of the preceding experiment?

145. ***Experiment 27.*** *Rise of Sap in Leaves.* — Put the freshly cut ends of the petioles of several thin leaves of different kinds into small glasses, each containing red ink to the depth of one-quarter inch or more. Allow them to stand for half an hour, and examine them by holding up to the light and looking through them to see into what parts the red ink has risen. Allow some of the leaves to remain as much as twelve hours, and examine them again. The red-stained portions of the leaf mark the lines along which, under natural conditions, sap rises into it. Cut across (near the petiole or midrib ends) all the principal veins of some kind of large thin leaf. Then cut off the petiole and at once stand the cut end, to which the blade is attached, in red ink. Repeat with another leaf and stand in water. What do the results teach?

In order to prevent wilting, the rise of sap during the life of the leaf must have kept pace with the evaporation from its surface. A little calculation will show that the amount of water thus daily carried off through the foliage of a large tree or the grass-blades on a meadow is enormous. A medium-sized elm has been found to have about 7,000,000 leaves, presenting a surface of about five acres, and transpiring about seven and three-quarter tons in twelve hours of clear, dry weather. Long pasture-grass has been estimated to give off 106 tons of water to the acre in twenty-four hours.

These large amounts of water are absorbed, carried through the tissues of the plant, and then given off by the leaves simply because the plant-food contained in the soil-water is

[1] When the experiments on the hydrangea have been finished, it should be kept moderately watered and left sealed up until it is needed for a later experiment, § 157.

in a condition so diluted that great quantities of water must be taken in order to secure enough of the mineral and other substances which the plant demands from the soil.

Meadow hay contains about two per cent of potash, or 2000 parts in 100,000, while the soil-water of a good soil does not contain more than one-half part in 100,000 parts. It would therefore take 4000 tons of such water to furnish the potash for one ton of hay.[1]

146. *Accumulation of Mineral Matter in the Leaf.* — Just as a deposit of salt is found in the bottom of a seaside pool of salt water which has been dried up by the sun, so old leaves are found to be loaded with mineral matter, left behind as the sap drawn up from the roots is evaporated through the stomata. A bonfire of leaves makes a surprisingly large heap of ashes. An abundant constituent of the ashes of burnt leaves is *silica*, a substance chemically the same as sand. This the plant is forced to absorb along with the potash, compounds of phosphorus, and other useful substances contained in the soil-water; but since the silica is of hardly any value to most plants, it often accumulates in the leaf as so much refuse. Lime is much more useful to the plant than silica, but a far larger quantity of it is absorbed than is needed; hence it, too, accumulates in the leaf.

147. *Details of the Work of the Leaf.*[2] — A leaf has four important functions to perform:

(1) Fixation of carbon. (3) Excretion of water.
(2) Assimilation.[3] (4) Respiration.

[1] Since the root-hairs, by closely enwrapping particles of the soil, and by giving off small quantities of acid from their surfaces, exert a powerful action in dissolving from the soil whatever in it is soluble, they must take up from it a solution stronger than ordinary soil-water, and therefore must actually be able to supply the mineral food needed by the plant from a smaller quantity of water than is found by the calculation above given.

[2] See Kerner and Oliver's *Natural History of Plants*, vol. I, pp. 371–483.

[3] In many works on Botany, (1) and (2) are both compounded under the term assimilation.

148. *Absorption of Carbonic Acid Gas.* — Carbonic acid gas is a constant ingredient of the atmosphere, usually occurring in the proportion of about 4 parts in every 10,000 of air or $\frac{1}{25}$ of one per cent. It is a colorless gas, a compound of two simple substances or elements, carbon and oxygen, the former familiar to us in the forms of charcoal and graphite, the latter occurring as the active constituent of air.

Carbonic acid gas is produced in immense quantities by the decay of vegetable and animal matter, by the respiration of animals, and by all fires in which wood, coal, gas, or petroleum is burned.

Green leaves and the green parts of plants have the power of removing carbonic acid gas from the air (or in the case of some aquatic plants from water in which it is dissolved) and setting free part or all of the oxygen. This process is an important part of the work done by the plant in making over raw materials into food from which it forms its own substance.

149. ***Experiment 28.*** *Oxygen-Making in Sunlight.* — Place a green aquatic plant in a glass jar full of fresh water, in front of a sunny window.[1] Note the rise of oxygen bubbles. Remove to a dark closet for a few minutes and examine by lamplight, to see whether the rise of bubbles still continues.

This gas may be shown to be oxygen by collecting some of it in a small inverted test-tube filled with water, and thrusting the glowing coal of a match just blown out into the gas. It is not, however, very easy to do this satisfactorily before the class.

Repeat the experiment, using water which has been well boiled and then quickly cooled. Boiling removes all the dissolved gases from water, and they are not re-dissolved in any considerable quantity for many hours.

Ordinary air, containing a known per cent of carbonic acid gas, if

[1] *Elodea*, *Myriophyllum*, *Chrysosplenium*, *Fontinalis*, any of the aquatic green flowering plants, or even the common confervaceous plants known as *pondscum* or "frog-spit," will do for this experiment.

passed very slowly over the foliage of a plant covered with a bell glass and placed in full sunlight, will, if tested chemically, on coming out of the bell glass be found to have lost a little of its carbonic acid. The pot in which the plant grows must be covered with a lid, closely sealed on, to prevent air charged with carbonic acid gas (as the air of the soil is apt to be) from rising into the bell glass.

150. *Disposition made of the Absorbed Carbonic Acid Gas.* — It would lead the student too far into the chemistry of botany to ask him to follow out in detail the changes by which carbonic acid gas lets go part at least of its oxygen, and gives its remaining portions, namely the carbon, and perhaps part of its oxygen, to build up the substance of the plant. Starch is composed of three elements: Hydrogen (a colorless, inflammable gas, the lightest of known substances), carbon, and oxygen. Water is composed largely of hydrogen, and, therefore, carbonic acid gas and water contain all the elements necessary for making starch. The chemist cannot put these elements together to form starch, but the plant can do it, and starch-making goes on constantly in the green parts of plants when exposed to sunlight and supplied with water and carbonic acid gas. The seat of the manufacture is in the chlorophyll bodies, and protoplasm is without doubt the manufacturer, but the process is difficult to understand. No carbonic acid can be taken up and used by plants growing in the dark.

A very good comparison of the leaf to a mill has been made as follows:[1]

The mill:	Parenchyma cells of the leaf.
Raw material used:	Carbonic acid gas, water.
Milling apparatus:	Chlorophyll grains.
Energy by which the mill is run:	Sunlight.
Manufactured product:	Starch.
Waste product:	Oxygen.

[1] By Professor Geo. L. Goodale.

151. *Plants Destitute of Chlorophyll not Starch-Makers.* — Aside from the fact that newly formed starch-grains are first found in the chlorophyll bodies of the leaf and the green

FIG. 100. — A Group of Indian Pipe Plants (*Monotropa uniflora*). Saprophytes and colorless.

layer of the bark, one of the best evidences of the intimate relation of chlorophyll to starch-making is derived from the fact that plants which contain no chlorophyll cannot make

starch from water and carbonic acid gas. Parasites, like the dodder, which are destitute of green coloring-matter, cannot do this, neither can *saprophytes* or plants which live on decaying or fermenting organic matter, animal or vegetable. Most saprophytes, like the moulds, toadstools, and yeast, are flowerless plants of low organization, but there are a few (such as the Indian pipe, Fig. 100, which flourishes on rotten wood or among decaying leaves) that bear flowers and seeds.

152. *Detection of Starch in Leaves.* — Starch may be found in abundance by microscopical examination of the green parts of growing leaves, or its presence may be shown by testing the whole leaf with iodine solution.

FIG. 101. — Leaf of Tropæolum partly covered with Disks of Cork and exposed to Sunlight.

153. Experiment 29. *Occurrence of Starch in Nasturtium Leaves.* — Boil some bean leaves or leaves of nasturtium (*Tropæolum*) in water for a few minutes to kill the protoplasmic contents of the cells and to soften and swell the starch-grains.

Soak the leaves (after boiling) in strong alcohol for a day or two to dissolve out the chlorophyll, which would otherwise make it difficult to see the blue color of the starch test, if any were obtained. Rinse out the alcohol with plenty of water and then place the leaves for half an hour in a solution of iodine, rinse off with water and note what portions of the leaf, if any, show the presence of starch.

154. Experiment 30. *Consumption of Starch in Nasturtium Leaves.* — Select some healthy leaves of Tropæolum on a plant growing vigorously indoors or, still better, in the open air. Shut off the sunlight from parts of the selected leaves (which are to be left on the plant and as little injured as may be) by pinning circular disks of cork on opposite sides of the leaf, as shown in Fig. 101. On the afternoon of the next day remove these leaves from the plant and treat as described in the preceding experiment, taking especial pains to get rid of all the chlorophyll by changing the alcohol as many times as may be necessary. What does this experiment show in regard to the consumption of starch in the leaf? What has caused its disappearance?

155. *Assimilation.* — The fixation of carbonic acid, by combining a part of its constituents with a part of the constituents of water, to form starch, is only one special, though very important, case of *assimilation*, that is, of the manufacture by the plant, from foreign materials, of the chemical compounds which make up its substance. A rather better term than assimilation is *constructive metabolism*. Besides carbonic acid gas and water, ordinary green plants require as food some compound of nitrogen, such as nitrates and ammonium compounds, sulphur and phosphorus, in suitable combinations, compounds of iron, calcium, potassium, and, perhaps, of sodium and of chlorine.[1]

These substances are found occurring in minute quantities in the soil-water and in ordinary flowering plants are brought to the parenchyma cells of the leaves or of the green layer of the bark to be worked over into the constituents of the plant. All parts of the process are due to the activity of the *protoplasm* contained in the cells of the working portions of the plant. Protoplasm is the jelly-like or semi-fluid proteid substance to which the life and working power of every active cell are due. The student has already become acquainted with protoplasm, since most of the tissues which he has examined, except the epidermis, the dead portions of the corky layer of the bark, the heartwood, and the dry pith, have been composed of cells which contained much protoplasm and some of which, as the cambium layer, contained little else but protoplasm.

156. *Non-Constructive Metabolism.*[2] — Side by side with the transformation of the inorganic substances drawn from earth and air into starch, protoplasm and other characteristic vegetable substances, there occur a series of other changes

[1] There is evidently room for the teacher, if he wishes, to do much in the way of exhibiting to the class the chemical compounds from which, as raw materials, plants manufacture their tissues.

[2] See Kerner and Oliver's *Natural History of Plants*, vol. I, pp. 455–465.

known by the general name of metabolism. The change of starch into grape sugar or maltose is a characteristic instance of the non-constructive kind of metabolism. It is essential to the growth of the plant that many and complicated transformations of material should occur within it; for example, starch, oil, and such insoluble proteids as are deposited in the outer portion of the kernel of wheat and other grains are extremely well adapted to serve as stored nutriment, but, on account of their insoluble nature, are quite unfit to circulate through the tissues of the plant. The various kinds of sugar, on the other hand, are not well adapted for storage, since they ferment easily in the presence of warmth and moisture.

By metabolic processes the tissues of the plant and their contents are all constructed out of certain formative materials. From starch, sugars, or fats, cellulose, the material of ordinary cell walls, is made, and from various proteids protoplasm and the chlorophyll bodies are produced.

Two important differences between fixation of carbon and the non-constructive or destructive type of metabolism should be carefully noticed. Destructive metabolism goes on in the dark as well as in the light, and it does not add to the total weight of the plant.

157. *Excretion of Water and Respiration.* — Enough has been said in § 145 concerning the former of these processes. *Respiration* or breathing in oxygen and giving off carbonic acid gas is an operation which goes on constantly in plants, as it does in animals, and is necessary to their life. For, like animals, plants get the energy with which they do the work of assimilation, growth, reproduction, and performing their movements, from the oxidation or burning up of such combustible substances as they can use for that purpose: for instance, starch and sugar.[1]

[1] The necessity of an air supply about the roots of the plant may be shown by filling the pot or jar in which the hydrangea was grown, for the transpiration experiment, perfectly full of water and noting the subsequent appearance of the plant at periods 12 to 24 hours apart.

The amount of oxygen absorbed and of carbonic acid given off, is, however, so trifling compared with the amount of each gas passing in the opposite direction, while fixation of carbon is going on in sunlight, that under such circumstances it is difficult to observe the occurrence of respiration at all. In ordinary leafy plants the leaves (through their stomata) are the principal organs for absorption of air, but a good deal of air passes into the plant through the lenticels of the bark.

158. *The Fall of the Leaf.* — In the tropics trees retain most of their leaves the year round; a leaf occasionally falls, but no considerable portion of them drops at any one season.[1] The same statement holds true in regard to our cone-bearing evergreen trees, such as pines, spruces, and the like. But the impossibility of absorbing soil-water when the ground is at or near the freezing temperature (§ 142) would cause the death, by drying up, of trees with broad leaf-surfaces in a northern winter. And in countries where there is much snow-fall, most broad-leafed trees could not escape injury to their branches from overloading with snow, except by encountering winter storms in as close-reefed a condition as possible. For such reasons our common shrubs and forest trees (except the cone-bearing, narrow-leafed ones already mentioned) are mostly *deciduous*, that is, they shed their leaves at the approach of winter.

159. *Chemical Changes in the Leaf before its Fall.* — The fall of the leaf is preceded by important changes in the contents of its cells.

Experiment 31. — *Does the Leaf vary in its Starch Contents at Different Seasons?*

Collect in early summer some leaves of several kinds of trees and shrubs, and preserve them in alcohol. Collect others as they are beginning to drop from the trees in autumn, and preserve them in the same way. Test some of each lot for starch as described in § 153.

What does the result indicate?

[1] Except where there is a severe dry season.

Much of the sugary and protoplasmic contents of the leaf disappears before it falls. These valuable materials have been absorbed by the branches and roots, to be used again the following spring.

The separation of the leaf from the twig is accomplished by the formation of a layer of cork cells across the base of the petiole in such a way that the latter finally breaks off across the surface of the layer. A waterproof scar is thus already formed before the removal of the leaf, and there is no waste of sap dripping from the wound where the leaf-stalk has been removed, and no chance for moulds to attack the bark or wood and cause it to decay. In compound leaves each leaflet may become separated from the petiole as the latter does from its attachment to the twig, as is notably the case with the horse-chestnut leaf (Fig. 75), or in a few kinds of simple leaves the blade may separate from its petiole, as it does in the Boston ivy (*Ampelopsis Veitchii*).

The brilliant coloration, yellow, scarlet, deep red and purple, of autumn leaves is popularly but wrongly supposed to be due to the action of frost. It depends merely on the changes in the chlorophyll grains and the liquid cell contents that accompany the withdrawal of the proteid material from the tissues of the leaf. The chlorophyll turns into a yellow insoluble substance after the valuable materials which accompany it have been taken away, and the cell-sap at the same time may turn red. Frost perhaps hastens the break-up of the chlorophyll, but individual trees often show bright colors long before the first frost, and in very warm autumns most of the changes in the foliage may come about before there has been any frost.

CHAPTER XIII.

Protoplasm and its Properties.[1]

160. *The Cell in its Simplest Form.* — Sufficient has been said in the preceding chapters, and enough tissues have been microscopically studied, to make it pretty clear what vegetable cells, as they occur in flowering plants, are like. But in studying the minute anatomy of bark, wood, pith, and other tissues, the attention is often directed to the *cell wall*, without much regard to the nature of the *cell contents*. Yet the cell wall is not the cell, any more than the lobster-shell or the crayfish-shell is the lobster or the crayfish. *The protoplasm is the cell.*[2] The cell, reduced to its lowest terms, need not have a cell wall, but may consist simply of a mass of protoplasm, usually containing a portion of denser consistency than the main bulk, known as the *nucleus*.

Such cells, without a cell wall, are not common in the vegetable world, but are frequently met with among animals.

161. *The Slime-Moulds.*[3] — The best example, among plants, of masses of naked protoplasm leading an individual existence is found in the slime moulds, which live upon rotten tan bark, decaying wood, and so on. These, like most flowerless plants, spring from minute bodies called *spores*, Fig. 102, *a*, which differ from the seeds of flowering plants, not only in

[1] If the teacher prefers to complete the study of the structure and functions of flowering plants before taking up lower forms, he may omit the present and the following chapter until after the flower and the fruit have been studied. It seems better to the author, however, to introduce the morphology and physiology of cells as individuals pretty early, and there are many reasons for taking up these topics immediately after Chapter IV.

[2] See Kerner and Oliver's *Natural History of Plants*, vol. I, pp. 21–51.

[3] Strasburger, Noll, Schenk, and Schimper, *Lehrbuch*, pp. 43, 44, 264, 265.

their microscopic size, but still more in their lack of an embryo. The spores of slime-moulds are capable, when kept dry, of preserving for many years their power of germination,

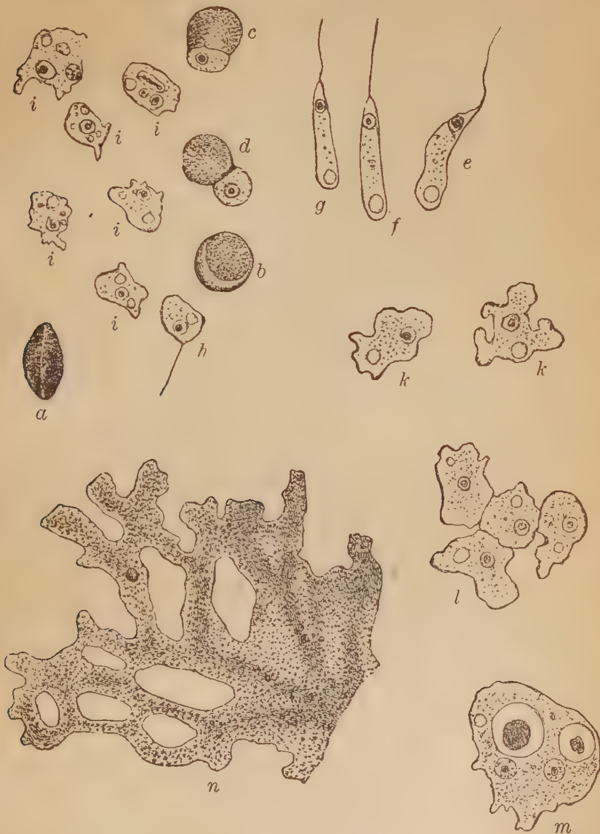


FIG. 102.—A Slime-Mould. (*a–m*, inclusive, magnified 540 times, *n* magnified 90 times.)

but in the presence of moisture and warmth they will germinate as soon as they are scattered. During the process of

germination the spore swells as shown at *b* and then bursts, discharging its protoplasmic contents, as seen at *c* and *d*. This in a few minutes lengthens out and produces at one end a hair-like *cilium*, as shown at *e*, *f*, *g*. These ciliated bodies are called *swarm-spores*, from their power of swimming freely about by the vibrating motion of the cilia. Every swarm-spore has at its ciliated end a *nucleus*, and at the other end a bubble-like object which gradually expands, quickly disappears, and then again expands. This *contractile vacuole* is commonly met with in animalcules, and increases the likeness between the slime-moulds and many microscopic animals. The next change of the swarm-spores is into an *Amœba-form* (so-called from one of the most interesting and simplest of animals, the *Amœba*, found on the surface of mud and the leaves of water-plants). In this condition, as shown at *h*, *i*, *k*, the spores creep about over the surface of the decaying vegetable material on which the slime-moulds live. Their movement is caused by a thrusting out of the semi-liquid protoplasm on one side of the mass, and a withdrawal of its substance from the other side. At length many amœba-shaped bodies unite, as at *l*, to form a larger mass, *m*, which finally increases to the protoplasmic network shown at *n*. This eventually collects into a roundish or egg-shaped, firm body, inside of which a new crop of spores is produced. It is not easy to trace the manner in which the nourishment of these simple plants is taken. Probably they absorb it from the decaying matter upon which they live during their amœba-like period, and after they have formed the larger masses, *n*.

162. *Characteristics of Living Protoplasm.*[1] — The behavior of the slime-moulds during their growth and transformations, as just outlined, affords a fair idea of several of the remarkable powers which belong to living protoplasm, which have been summed up as follows :

[1] See Huxley's *Essays*, vol. I, essay on "The Physical Basis of Life."

(1) The power to take up new material into its own substance (*selective absorption*). This is not merely a process of soaking up liquids, such as occurs when dry earth or a sponge is moistened. The protoplasmic lining of a root-hair, for example, selects from the soil-water some substances and rejects others.

(2) The ability to change certain substances into others of different chemical composition (*metabolism*, §§ 155, 156). Carbonic acid gas and water, losing some oxygen in the process, are combined into starch ; starch is changed into various kinds of sugar and these back into starch again; or starch becomes converted into vegetable acids, into cellulose, or into oil. Many other more complicated transformations occur.

(3) The power to cast off waste or used up material (*excretion*). Getting rid of surplus water (§ 145) and of oxygen (§§ 148, 149, 150) constitutes a very large part of the excretory work of plants.

(4) The capacity for growth and the production of offspring (*reproduction*). These are especially characteristic of living protoplasm. It is true that non-living objects may grow in a certain sense, as an icicle or a crystal of salt or of alum in a solution of its own material does. But growth by the process of taking suitable particles into the interior of the growing substance and arranging them into an orderly structure is possible only in the case of live protoplasm.

(5) The possession of the power of originating movements not wholly and directly caused by any external impulse (*automatic movements*). Such, for instance, are the lashing movements of the cilia of the swarm-spores of slime-moulds or of the motile cells of the minute plants known as *Protococcus* (§ 268), or the slow vibrating movements of the stipules of the "telegraph plant" (*Desmodium*), not uncommon in greenhouses.

(6) The power of shrinking or closing up (*contractility*).

This is illustrated by the action of the contractile vacuole of the slime-moulds and of many animalcules as well as by the movements of leaves which act as insect-traps (§ 130) and by all the muscular movements of animals.

(7) Sensitiveness when touched or otherwise disturbed (*irritability*). This is shown by insect-catching leaves (§ 130), by the leaves of the common sensitive-plants, and by some parts of certain flowers (§ 209).

(1), (2), and (3) are not so readily studied in the slime-moulds as in some other plants, but unless one can believe in the manufacture of something out of nothing, he must conclude that these simple plants make their growth at the expense of materials drawn from the water and the decaying matter on which they are found.[1]

FIG. 103. — Stinging Hair of Nettle, with Nucleus. The arrows show the direction of the currents in the protoplasm.

163. *Circulation of Protoplasm.* — When confined by a cell wall, protoplasm often manifests a beautiful and constant rotating movement, traveling incessantly up one side of the cell and down the other.[2] A more complicated motion is the *circulation of protoplasm*, shown in cells of the jointed blue hairs in the flower of the common spiderwort and in the stinging hairs of the nettle (Fig. 103). The thin cell wall of each hair is lined with a protoplasmic layer in which are seen many irregular, thread-like currents, marked by the movements of the granules of which the protoplasmic layer is full.

[1] It would of course be well for the pupil to make careful studies of *Amœba* and of one or more of the ciliated animalcules. If time will admit of this, the teacher may consult Huxley and Martin's *Elementary Biology*, under *Amœba* and *Vorticella*.

[2] See Huxley and Martin, under *Chara*.

s are produced from
lateral or terminal bud.

CHAPTER XIV.

Inflorescence, or Arrangement of Flowers on the Stem.

164. *Regular Positions for Flower-Buds.* — Flower-buds, like leaf-buds, occur regularly either in the axils of leaves or at the end of the stem or branch (see § 187) and are therefore either axillary or terminal.

165. *Axillary and Solitary Flowers; Indeterminate Inflorescence.* — The simplest possible arrangement for flowers which arise from the axils of leaves is to have a single flower spring from each leaf-axil. Fig. 104 shows how this plan appears in a plant with opposite leaves. As long as the stem continues to grow, the production of new leaves may be followed by that of new flowers. Since there is no definite limit to the number of flowers which may appear in this way, the mode of flowering just described (with many others of the same general character) is known as *indeterminate inflorescence.*

FIG. 104. — Axillary and Solitary Flowers of Pimpernel.

FIG. 105. — Raceme of Common Red Currant; *p.*, peduncle; *p'.*, pedicel; *br.*, bract.

The Raceme and Related Forms. — If the leaves along the stem were to become very much dwarfed and the flowers brought closer together, as they frequently are, a kind of flower-cluster like that of the currant (Fig. 105) or the lily of the valley would result. Such an inflorescence is called a *raceme;* the main flower stalk is known as the *peduncle;* the little individual flower stalks are *pedicels,* and the small, more or less scale-like leaves of the peduncle are *bracts.*[1]

Frequently the lower pedicels of a cluster on the general plan of the raceme are longer than the upper ones and make a somewhat flat-topped cluster, like that of the hawthorn, the sheep laurel, or the trumpet creeper. This is called a *corymb.*

FIG. 106.—Simple Umbel of Cherry.

In many cases, for example the parsnip, the sweet cicely, the ginseng and the cherry, a group of pedicels of nearly equal length spring from about the same point. This produces a flower-cluster called the *umbel* (Fig. 106).

166. *Sessile Flowers and Flower-Clusters.* — Often the pedicels are wanting, or the flowers are sessile, and then a modification of the raceme is produced which is called a *spike,* like that of the plantain (Fig. 107). The willow, alder, birch, poplar, and many other common trees bear a short, flexible, rather scaly spike (Fig. 108), which is called a *catkin.*

The peduncle of a spike is often so much shortened as to bring the flowers into a somewhat globular mass. This is

[1] It is hardly necessary to say that the teacher will find it better in every way, if material is abundant, to begin the study of flower-clusters with the examination of typical specimens by the class.

called a *head* (Fig. 109). Around the base of the head usually occurs a circle of bracts known as the *involucre*, well shown in Fig. 110. The same name is given to a set of bracts which often surround the bases of the pedicels in an umbel.

167. *The Anthodium.* — The plants of one large group, of which the dandelion, the daisy, the thistle, and the sunflower

FIG. 107. — Spike of Plantain.

FIG. 108. — Catkins of Willow. I, Staminate flowers; II, Pistillate flowers.

FIG. 109. — Head of Eryngo.

are well-known members, bear their flowers in close involucrate heads on a common receptacle. The whole cluster looks so much like a single flower that it is usually taken for one by non-botanical people. This kind of head has received the special name of *anthodium*. In many of the largest and

most showy anthodia like the sunflower and the daisy there are two kinds of flowers, the *ray-flowers*, around the margin, and the tubular *disk-flowers* of the interior of the head, Fig. 110.[1] The early botanists supposed the whole flower cluster to be a single compound flower. This belief led to their naming one family of plants *Compositæ*, that is plants with compound flowers. In such anthodia as those of the thistle, the cud-weed and the everlasting there are no ray-flowers, and in others, like those

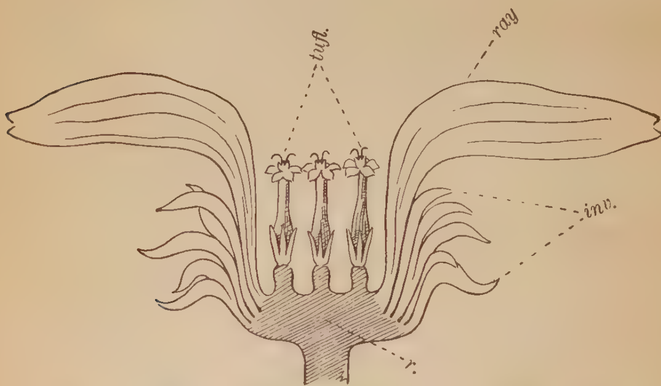


FIG. 110. — Vertical Section of Anthodium of a Sunflower (diagram). *inv.*, involucre; *ray*, ray-flower; *tu.-fl.*, tubular flowers of disk; *r.*, common receptacle.

of the dandelion and the chicory, all the flowers are ray-flowers.

168. *Compound Flower-Clusters.* — If the pedicels of a raceme branch, they may produce a compound raceme, or *panicle*, like that of the oat (Fig. 111).[1] Other forms of compound racemes have received other names.

An umbel may become compound by the branching of its

[1] Each disk-flower arises from the axil of a bract, not shown in the figure.

[2] Panicles may also be formed by compound cymes, see § 165.

flower-stalks (Fig. 112), each of which then bears a little umbel, an *umbellet.*

FIG. 111. — Panicle of Oat.

FIG. 112. — Compound Umbel of Chervil.

169. *Inflorescence Diagrams.* — The plan of inflorescence may readily be indicated by diagrams like those of Fig. 113.

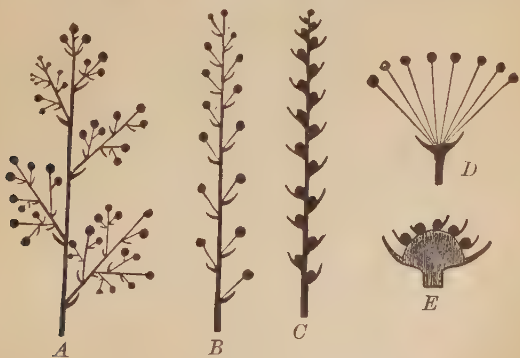


FIG. 113. —Diagrams of Inflorescence.
A, panicle ; *B*, raceme ; *C*, spike ; *D*, umbel[1] ; *E*, head.[1]

[1] In these diagrams the balls, which symbolize flowers, should be largest at the outside and diminish regularly toward the centre, to show that the outermost flowers are the oldest.

The student should construct such diagrams for some rather complicated flower-clusters like those of the grape, horse-chestnut or buckeye, hardhack, vervain, or many grasses.

170. *Terminal Flowers. Determinate Inflorescence.* — The terminal bud of a stem may be a flower-bud. In this case the direct growth of the stem is stopped or determined by the appearance of the flower, hence such plants are said to have a *determinate inflorescence.* The simplest possible case of this kind is that in which the stem bears but one flower at its summit.

FIG. 114. — Compound Cyme of Mouse-Ear Chickweed.
t, the terminal (oldest) flower.

171. *The Cyme.*—Very often flowers appear from lateral (axillary) buds, below the terminal flower, and thus give rise to a flower-cluster called a *cyme.* This may have only three flowers, and in that case would look very much like a three-flowered umbel. But in the raceme, corymb, and umbel the order of flowering is from below upward, or from the outside of the cluster inward, because the lowest, or the outermost flowers, are the oldest, while in determinate forms of inflorescence the central flower is the oldest, and therefore the order of blossoming is from the centre outwards. Cymes are very commonly compound, like those of the elder and of many plants of the pink family, such as the Sweet William and the mouse-ear chickweed (Fig. 114). They may also, as already mentioned, be panicled, thus making a cluster much like Fig. 113 *A*.

CHAPTER XV.

The Study of Typical Flowers.[1]

(Only one of the three flowers described to be studied by aid of these directions.)

172. *The Flower of the Trillium.* — Cut off the flower stalk rather close to the flower; stand the latter, face down, on the table, and draw the parts then shown. Label the three green leaflike parts *sepals*, and the three white parts which alternate with these *petals*. Turn the flower face up, and make another sketch, labeling the parts as before, together with the yellow enlarged extremities or *anthers* of the six stamens.

Note the way in which the petals alternate with the sepals; *i.e.*, each petal springs from a point just above the space between two sepals. Observe the arrangement of the edges of the petals toward the base — one petal with both edges outside the other two, one with both edges inside, the third with one edge in and one out.

Note the veining of both sepals and petals, more distinct in the former.[2]

[1] The buttercup and the trillium are suggested because they are early spring flowers, of which some species may be found in most of the states east of the Mississippi. They are tolerably large flowers, simple in their plan, differ much in the number and shape of the floral organs, and are respectively somewhat typical of large groups. Other flowers should be studied in much detail when the class is completing Chapter XIX. The description of the flower of the trillium, as found in this chapter, is true in details only of the white variety of *T. erectum*, but the account given would serve as a guide for the study of any of our species. The buttercup flower here described is that of *Ranunculus bulbosus*, but the description will hold good in the main for any of the larger-flowered species. The tulip is perhaps the simplest polypetalous and regular flower which can be had of florists as early as May 1, and therefore in ample time to serve as an introduction (for city pupils) to the study of floral structures. If the expense of procuring tulips enough for class study should make it impossible to use them, the teacher could easily make out a set of directions for the study of some such flower as the (slightly irregular) *pelargoniums*.

Sedum acre can very easily be supplied in quantity, if arrangements are made with florists to have it ready.

[2] In flowers with delicate white petals the distribution of the fibro-vascular bundles in these can usually be readily shown by standing the freshly-cut end of the peduncle in red ink for a short time, until colored veins begin to appear in the petals. The experiment succeeds readily with apple, cherry, or plum blossoms; with white gilliflower the coloration is very prompt. Lily of the valley is perhaps as interesting a flower as any on which to try the experiment, since the well-defined stained stripes are separated by portions quite free from stain, and the pistils are also colored.

Pull off a sepal and make a sketch of it, natural size; then remove a petal, flatten it out, and sketch it, natural size.

Observe that the flower-stalk is enlarged slightly at the upper end into a rounded portion, the *receptacle*, from which all the parts of the flower spring.

Note how the six stamens arise from the receptacle, three of them from points just within and above the origins of the petals, the other three from points between the petals. Remove the remaining petals (cutting them off near the bottom with a knife), and sketch the stamens, together with another object, the *pistil*, which stands in the centre.

Cut off one stamen, and sketch it as seen through the magnifying glass. Notice that it consists of a greenish stalk, the *filament*, and a broader portion, the *anther*, Fig. 116, *B*. The latter is easily seen to contain a prolongation of the green filament, nearly surrounded by a yellow substance. In the bud it will be found that the anther consists of two long pouches or *anther-cells*, which are attached by their whole length to the filament, and face inward (towards the centre of the flower). When the flower is fairly open, the anther-cells have already split down their margins, and are discharging a yellow, somewhat sticky powder, the *pollen*.

Examine one of the anthers with the microscope, using the two-inch objective (No. 1), and sketch it.

Cut away all the stamens, and sketch the pistil. It consists of a stout lower portion, the *ovary*, which is six-ridged or angled, and which bears at its summit three slender *stigmas*.

In another flower, which has begun to wither (and in which the ovary is larger than in a newly-opened flower), cut the ovary across about the middle, and try to make out with the magnifying glass the number of chambers or *cells* which it contains. Examine the cross-section with the two-inch objective; sketch it, and note particularly the appearance and mode of attachment of the undeveloped seeds or *ovules* with which it is filled. Make a vertical section of another rather mature ovary, and examine this in the same way.

Using a fresh flower, construct a diagram to show the relation of the parts on an imaginary cross-section, as illustrated in Fig. 135.[1] Construct a diagram of a longitudinal section of the flower, on the general plan of those in Fig. 133, but showing the contents of the ovary.

[1] It is important to notice that such a diagram is not a picture of the section actually produced by cutting through the flower crosswise at any one level, but that it is rather a *projection* of the sections through the most typical part of each of the floral organs.

173. *The Flower of the Tulip.*[1] — Make a diagram of a side view of the well-opened flower, as it appears when standing in sunlight. Observe that there are three outer flower leaves and three inner ones.[2] Label the outer set *sepals* and the inner set *petals*. In most flowers the parts of the outer set are greenish, and those of the inner set of some other color. In cases like the present, where the coloration is the same throughout, the name *perianth*, meaning around the flower, is applied to the two sets taken together. Note the white waxy bloom on the outer surface of the three outer segments of the perianth. What is the use of this? Note the manner in which the three inner segments of the perianth arise from the top of the peduncle, just above and alternating with the points of attachment of the three outer segments. In a flower not too widely opened, note the relative position of the three inner segments of the perianth, one wholly outside the other two, one wholly inside, the third with one edge in and one edge out.

Remove one of the sepals by cutting it off close to its attachment to the peduncle, and examine the veining by holding it up in a strong light and looking through it. Make a sketch to show the general outline and the shape of the tip.

Examine a petal in the same way, and sketch it.

Cut off the remaining portions of the perianth, leaving about a quarter of an inch at the base of each segment. Sketch the upright, triangular, pillar-like object in the centre, label it *pistil*, sketch the six organs which spring from around its base, and label these *stamens*.

Note the fact that each stamen arises from a point just above and within the base of a segment of the perianth. Each stamen consists of a somewhat conical or awl-shaped portion below, the *filament*, surmounted by an ovate linear portion, the *anther*. Sketch one of the stamens about twice natural size. Is the attachment of the anther to the filament such as to admit of any nodding or twisting movement of the former? In a young flower, note the two tubular pouches or anther-cells of which the anther is composed, and the slits by which these open. Observe the dark-colored *pollen* which escapes from the anther-cells and adheres to paper or to the fingers. Examine a newly opened anther with the microscope, using the two-inch objective, and sketch it.

Cut away all the stamens and note the two portions of the pistil, a triangular prism, the *ovary*, and three roughened scroll-like objects at the

[1] *Tulipa Gesneriana.* As the flowers are rather expensive, and their parts are large and firm, it is not absolutely necessary to give a flower to each pupil, but some may be kept entire for sketching and others dissected by the class. All the flowers must be single.

[2] Best seen in a flower which is just opening.

top, the three lobes of the *stigma*. Make a sketch of these parts about twice the natural size, and label them. Touch a small camel's-hair pencil to one of the anthers, and then transfer the pollen thus removed to the stigma. This operation is merely an imitation of the work done by insects which visit the flowers out of doors. Note how readily the pollen clings to the rough stigmatic surface. Examine this adhering pollen with the two-inch objective, and sketch a few grains of it, together with the bit of the stigma to which it clings. Compare this drawing with Fig. 140. Make a cross-section of the ovary about midway of its length, and sketch the section as seen through the magnifying glass. Label the three chambers shown, *cells of the ovary*,[1] and the white egg-shaped objects within, *ovules*.[2]

Make a longitudinal section of another ovary, taking pains to secure a good view of the ovules, and sketch as seen through the magnifying glass.

Making use of the information already gained and the cross-section of the ovary as sketched, construct a diagram of a cross-section of the entire flower on the same general plan as those shown in Fig. 135.[3]

Split a flower lengthwise,[4] and construct a longitudinal section of the entire flower on the plan of those shown in Fig. 133, but showing the contents of the ovary.

174. *The Flower of the Buttercup.* — Make a diagram of the mature flower as seen in a side view, looking a little down into it. Label the five pale greenish yellow, hairy, outermost parts sepals, and the five[5] larger bright yellow parts above and within these petals, and the yellow-knobbed parts which occupy a good deal of the interior of the flower, *stamens*.

Note the difference in the position of the sepals of a newly opened flower and that of the sepals about a flower which has opened as widely as possible. Note the way in which the petals alternate with the sepals, *i.e.*, each petal springs from a point just above the space between two sepals. In an opening flower, observe the arrangement of the edges of the petals, two entirely outside the others, two entirely inside, one with one edge in and the other out.

Cut off a sepal and a petal, each close to its attachment to the flower;

[1] Notice that the word cell here means a comparatively large cavity, and is not used in the same sense in which we speak of a wood cell or a pith cell.

[2] The section will be more satisfactory if made from an older flower, grown out of doors, from which the perianth has fallen.

[3] Consult also the footnote on p. 138.

[4] One will do for an entire division of the class.

[5] Sometimes more.

place both, face down, on a sheet of paper, and sketch about twice the natural size. Describe the difference in appearance between the outer and the inner surface of the sepal and of the petal. Note the little scale at the base of the petal, inside.

Strip off all the parts from a flower which has lost its petals, until nothing is left but a slender conical object a little more than an eighth of an inch in length. This is the *receptacle* or summit of the peduncle.

In a fully opened flower, note the numerous yellow-tipped *stamens*, each consisting of a short stalk, the *filament*, and an enlarged yellow knob at the end, the *anther*. Note the division of the anther into two portions, which appear from the outside as parallel ridges, but which are really closed tubes, the *anther-cells*.

Observe in the interior of the flower the somewhat globular mass (in a young flower almost covered by the stamens). This is a group of *pistils*. Study one of these groups in a flower from which the stamens have mostly fallen off, and make an enlarged sketch of the head of pistils. Remove some of the pistils from a mature head, and sketch a single one as seen with the magnifying glass. Label the little knob or beak at the upper end of the pistil *stigma*, and the main body of the pistil *ovary*. Make a section of one of the pistils, parallel to the flattened surfaces, like that shown in Fig. 169, and note the partially matured seed or *ovule* within.

CHAPTER XVI.

Plan and Structure of the Flower and its Organs.

175. *Parts or Organs of the Flower.* — Most showy flowers consist, like those studied in the preceding chapter, of four circles or sets of organs, the sepals, petals, stamens, and pistils. The sepals, taken together, constitute the *calyx*, the petals, taken together, constitute the *corolla*, Fig. 115.[1] Some-

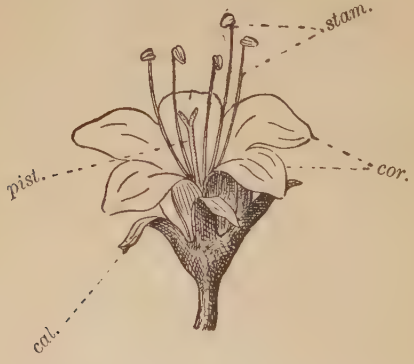


FIG. 115. — The Parts of the Flower.[2]
cal., calyx; *cor.*, corolla; *stam.*, stamens; *pist.*, pistil.

times it is convenient to have a word to comprise both calyx and corolla; for this the term *perianth* is used. A flower which contains all four of these sets is said to be *complete.* Since the work of the flower is to produce seed, and seed-forming is due to the coöperation of stamens and pistils, these are known

[1] The flower of the waterleaf or *Hydrophyllum*, modified by the omission of the hairs on the stamens, is here given because it shows so plainly the relation of the parts.

[2] *Hydrophyllum Canadense*, with appendages in throat of corolla and hairs on stamens omitted.

as the *essential organs*, Fig. 116. The simplest possible pistil is a dwarfed and greatly modified leaf (§ 188), adapted into a seed-bearing organ. Such a pistil may be one-seeded, as in Fig. 169, or several-seeded, as in the right-hand part of Fig. 171; it is called a *carpel*. The calyx and corolla are known

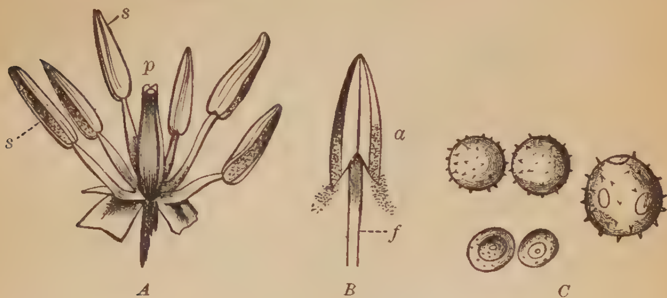


FIG. 116. — The Essential Organs.

A, stamens and pistil of a tulip (the perianth removed); *s*, stamens; *p*, pistil; *B*, a separate stamen, with its anther *a* discharging pollen; *f*, the filament; *C*, pollen-grains.

as the *floral envelopes*. Flowers which have the essential organs are called *perfect flowers*. They may therefore be perfect without being complete. In cases where the perianth contains only one row of parts, it is assumed that the petals are lacking. Such incomplete flowers are said to be *apetalous*, Fig. 117.

FIG. 117. — Apetalous Flower of (European) Wild Ginger.

176. *Regular and Symmetrical Flowers.* — A flower is regular if all the parts of the same set or circle are alike in size and shape, as in the stonecrop, Fig. 118. Such flowers as that of the violet, the monkshood, the nasturtium, or the laburnum, Fig. 119, are irregular. Symmetrical flowers are those whose calyx, corolla, circle of stamens and set of carpels consists each of the same number of parts, or in which the

number in every case is a multiple of the smallest number found in any set. The stonecrop is symmetrical, since it has five sepals, five petals, ten stamens, and five carpels. Roses, mallows, and mignonette are familiar examples of flowers

I II

FIG. 118.—Flower of Stonecrop.
I, entire flower (magnified); II, vertical section (magnified).

which are unsymmetrical because they have a large indefinite number of stamens; the Portulaca is unsymmetrical since it has two divisions of the calyx, five or six petals, and seven to twenty stamens.

I. II.

FIG. 119.—Irregular Corolla of Laburnum.
I, side view; II, front view.

177. *The Receptacle.*—The parts of the flower are borne on an expansion of the peduncle, called the *receptacle.* Usually, as in the flower of the grape, Fig. 145, this is only a slight enlargement of the peduncle, but in the lotus and the magnolia the receptacle is of great size, particularly after the

petals have fallen and the seed has ripened. The receptacle of the rose, Fig. 120, is hollow and the pistils arise from its interior surface.

178. *Imperfect or Separated Flowers.* — The stamens and pistils may be produced in separate flowers, which are, of course, *imperfect.* This term does not imply that such flowers do their work any less perfectly than others, but only that they have not both kinds of essential organs. In the very simple imperfect flowers of the willow, Fig. 121, each flower of the catkin, Fig. 108, consists merely of a pistil or a group of (usually two) stamens, springing from the axil of a small bract.

Fig. 120. — A Rose, Longitudinal Section.

Staminate and pistillate flowers may be borne on different plants, as they are in the willow, or they may be borne on the same plant, as in the hickory and the hazel, among trees, or in the castor-oil plant, Indian corn, and the begonias. When staminate and pistillate flowers are borne on separate plants, such a plant is said to be *diœcious,* that is, of-two-households; when both kinds of flower appear on the same individual, the plant is said to be *monœcious,* that is, of-one-household.

179. *Study of Imperfect Flowers.* — Examine, draw, and describe the imperfect flowers of some of the following diœcious plants and one of the monœcious plants[1]:

Diœcious plants	early meadow rue, willow, poplar.
Monœcious plants	walnut, oak, chestnut, hickory, alder, beech, birch, hazel, begonia.

[1] For figures and descriptions of these or allied flowers consult Gray's *Manual of Botany*, Emerson's *Trees and Shrubs of Massachusetts*, Newhall's *Trees of the Northern United States*, or Le Maout and Decaisne's *Traité Général de Botanique*.

180. *Union of Similar Parts of the Perianth.* — The sepals may join or *cohere* to form a calyx which is more or less entirely united into one piece, as in Figs. 115, 117. In this case the calyx is said to be *gamosepalous*, that is, of-wedded-sepals. In the same way the corolla is frequently *gamopetalous*, as in Figs. 122, 123. Special names are given to a large number of forms of the gamopetalous corolla, and these names are of great use in accurately describing plants; only a few of these names are here given, in connection with the figures.

When the parts of either circle of the perianth are wholly

I II

Fig. 121. — Flowers of Willow (magnified). I, staminate flower; II, pistillate flower.

Fig. 122. — Bell-Shaped Corolla of Bellflower (Campanula).

unconnected with each other, that is, polysepalous or polypetalous, they are said to be *distinct*.

181. *Parts of the Stamen and the Pistil.* — The stamen usually consists of a hollow portion, the *anther*, Fig. 127 *b*, borne on a stalk called the *filament*, Fig. 127 *a*. Inside the anther is a powdery or pasty substance called *pollen*. Not infrequently the filament is lacking. The pistil usually consists of a small hollow chamber, the *ovary*, which contains the ovules or rudimentary seeds, a slender portion or stalk, called the *style*, and at the top of this a ridge, knob, or point

called the *stigma*. These parts are all shown in Fig. 128. In many pistils the stigma is borne directly on the ovary, as in Fig. 145.

182. *Union of Stamens with each Other.* — Stamens may be wholly unconnected with each other or *distinct*, or they may cohere by their filaments into a single group, when they are said to be *monadelphous*, of-one-brotherhood, Fig. 129, into two groups (*diadelphous*), Fig. 130, or into many groups. In some flowers the stamens are held together in a ring by their coherent anthers, Fig. 131.

Fig. 123. — Salver-Shaped Corolla of Jasmine (magnified).

183. *Union of Pistils.* — The pistils may be entirely separate from each other, *distinct* and *simple* as they are in the buttercup and the stonecrop, or several may join to form one *compound pistil* of more or less united carpels. In the latter case the union generally affects the ovaries, but often leaves the styles separate, or it may result in joining ovaries and styles, but leave the stigmas separate or at any rate lobed, so as to show of how many separate carpels the compound pistil is made up. Even when there is no external sign to show the compound nature of the pistil, it can usually be recognized from the study of a cross-section of the ovary.

Fig. 124. — Wheel-Shaped Corolla of Potato.

184. *Cell of the Ovary; Placentas.* — Compound ovaries are very commonly several-celled, that is, they consist of a number of separate cells[1] or chambers. Fig. 132 *B* shows a

[1] Notice that the word cell is here used in an entirely different sense from that in which it has been employed in the earlier chapters of this book. As applied to the ovary, it means a chamber or compartment.

three-celled ovary, seen in cross-section. The ovules are not borne indiscriminately by any part of the lining of the ovary. In one-celled pistils they frequently grow in a line running along one side of the ovary, as in the pea pod, Fig. 176. The ovule-bearing line is called a *placenta;* in compound pistils there are commonly as many placentas as there are separate pistils joined to make the compound one. Placentas on the wall of the ovary, like those in Fig. 132 *A*, are called *parietal placentas;* those which occur as at *B*, in the same figure, are

FIG. 125. — Tubular Corolla, from Head of Bachelor's Button.

FIG. 126. — Labiate or Ringent Corolla of Dead Nettle.

FIG. 127. — Parts of a Stamen. *a*, filament; *b*, anther.

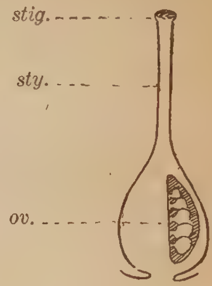


FIG. 128. — Parts of the Pistil. *ov.*, ovary; *sty.*, style; *stig.*, stigma.

said to be central, and those which, like the form represented in *C* of the same figure, consist of a column rising from the bottom of the ovary, are called *free central placentas.*

185. *Union of Separate Circles.* — The members of one of the circles of floral organs may join those of another circle, thus becoming *adnate, adherent*, or *consolidated.* In Fig. 117 the calyx-tube is adnate to the ovary. In this case the parts of the flower do not all appear to spring from the receptacle. Fig. 133 illustrates three common cases as regards insertion of the parts of the flower. In I they are

all inserted on the receptacle, and the corolla and stamens are said to be *hypogynous*, that is, beneath-the-pistil. In II the petals and the stamens appear as if they had grown fast to the calyx for some distance, so that they surround the pistil, and they are therefore said to be *perigynous*, that is, around-the-pistil. In III all the parts are *free* or uncon-

FIG. 129. — Monadelphous Stamens of Mallow.

FIG. 130. — Diadelphous Stamens of Sweet Pea.

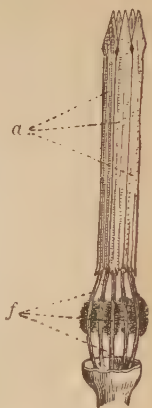


FIG. 131. — Stamens of a Thistle, with Anthers United into a Ring.

a, united anthers; *f*, filaments, bearded on the sides.

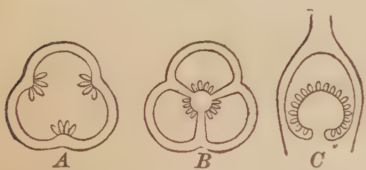


FIG. 132. — Principal Types of Placenta.

A, parietal placenta; *B*, central placenta; *C*, free central placenta; *A* and *B*, transverse sections; *C*, longitudinal section.

solidated, except the petals and stamens; the stamens may be described as *epipetalous*, that is, growing-on-the-petals. Sometimes some or all of the other parts seem to grow out of the ovary, and such parts are said to be *epigynous*, that is, on-the-ovary, like the petals and stamens of the white water-lily, Fig. 134.

186. *Floral Diagrams.* — Sections (real or imaginary)

through the flower lengthwise, like those of Fig. 133, help greatly in giving an accurate idea of the relative position of the floral organs. Still more important in this way are cross-sections, which may be recorded in diagrams like those of Fig. 135.[1] In constructing such diagrams it will often be necessary to suppose some of the parts of the flower to be raised or lowered from their true position, so as to bring

FIG. 133. — Insertion of the Floral Organs.

I, Hypogynous, all the other parts on the receptacle, beneath the pistil; II, Perigynous, petals and stamens apparently growing out of the calyx, around the pistil; III, corolla hypogynous, stamens epipetalous.

FIG. 134. — White Water-Lily. The inner petals and the stamens growing from the ovary.

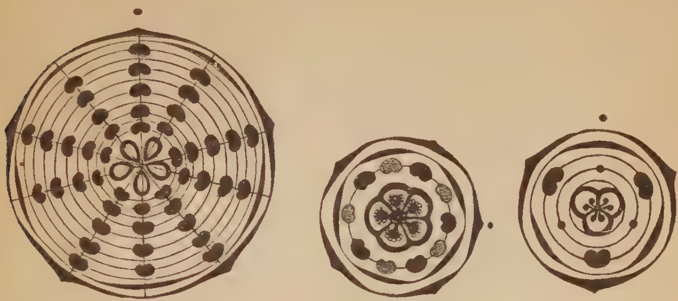
them into such relations that all could be cut by a single section. This would, for instance, be necessary in making a diagram for the cross-section of the flower of the white water-lily, of which a partial view of one side is shown in Fig. 134.[2]

Construct diagrams of the longitudinal section and the transverse section of several large flowers, following the

[1] For floral diagrams see *Thomé's Botany*, Le Maout and Decaisne's *Traité Général de Botanique*, or Eichler's *Blüthendiagramme*.

[2] It is best to begin practice on floral diagrams with flowers so firm and large that actual sections of them may be cut with ease and the relations of the parts in the section readily made out. The tulip is admirably adapted for this purpose.

method indicated in Figs. 133 and 135, but making the longitudinal section show the interior of the ovary.[1]



I II III

FIG. 135. — Diagrams of Cross-Sections of Flowers.

I, columbine ; II, heath family ; III, iris family. In each diagram the dot alongside the main portion indicates a cross-section of the stem of the plant. In II, every other stamen is more lightly shaded because some plants of the heath family have 5 and some 10 stamens.

[1] Among the many excellent early flowers for this purpose may be mentioned trillium, blood-root, dog-tooth violet, marsh marigold, buttercup, tulip tree, horse-chestnut, Jeffersonia, May-apple, cherry, apple, crocus, tulip, daffodil, primrose, wild ginger, cranesbill, locust, bluebell.

CHAPTER XVII.

True Nature of Floral Organs; Details of their Structure.

187. *The Flower a Shortened and Greatly Modified Branch.* —In Chapter IX, the leaf-bud was explained as being an undeveloped branch, which in its growth would develop into a real branch (or a prolongation of the main stem). Now since flower-buds appear regularly either in the axils of leaves or as terminal buds, there is reason to regard them as of similar nature to leaf-buds. This would imply that the receptacle corresponds to the axis of the bud shown in Fig. 60, and that the parts of the flower correspond to leaves. There is plenty of evidence that this is really true. Sepals frequently look very much like leaves, and in many cactuses the bracts about the flower are so sepal-like that it is impossible to tell where the bracts end and the sepals begin. The same thing is true of

FIG. 136. — Transitions from Petals to Stamens in White Water-Lily.
E, F, G, H, various steps between petal and stamen.

sepals and petals in such flowers as the white water-lily. In this flower there is a remarkable series of intermediate steps ranging all the way from petals, tipped with a bit of anther, through stamens with a broad petal-like filament to regular stamens, as is shown in Fig. 136, E, F, G, H. The same thing is shown in many double roses (Fig. 137). In completely double flowers all the essential organs are transformed by cultivation into petals. In the flowers of the cultivated double cherry the pistils occasionally take the form of small leaves, and some roses turn wholly into green leaves.

Summing up, then, we know that flowers are altered and shortened branches: (1) because flower-buds have the same

FIG. 137. — Transitions between Petals and Stamens in a Rose.

kinds of origin as leaf-buds; (2) because all the intermediate steps are found between bracts on the one hand and stamens on the other; (3) because the essential organs are found to be replaced by petals or even by green leaves.

188. *Mode of Formation of Stamens and Pistils from Leaves.* — It is hardly possible to state, in a book for beginners, how stamens stand related to leaves.[1]

The simple pistil or *carpel* is supposed to be made on the plan of a leaf folded along the midrib until its margins touch, like the cherry leaf in Fig. 61. But the student must not understand by this statement that the little pistil leaf grows

[1] "The anther answers exactly to the spore-cases of the ferns and their allies, while the filament is a small specialized leaf to support it." For a fuller statement, see Potter's Warming's *Systematic Botany*, pp. 236, 237.

at first like an ordinary leaf and finally becomes folded in. What really occurs is this: the flower-bud, as soon as it has developed far enough to show the first rudiments of the essential organs, contains them in the form of minute knobs. These are developed from the tissues of the plant in the same manner as are the knobs in a leaf-bud, which afterwards become leaves; but as growth and development progress in the flower-bud, its contents soon show themselves to be stamens and pistils (if the flower is a perfect one). The united leaf margins near the tip would form the stigma, and the placenta would correspond to the same margins, rolled slightly inwards, extending along the inside of the inflated leaf pouch. Place several such folded leaves upright about a common center, and their cross-section would be much like that of B in Fig. 132. Evidence that carpels are really formed in this way may be gained from the study of such fruits as that of the monkshood (Fig. 171), in which the ripe carpels may be seen to unfold into a shape much more leaf-like than that which they had while the pistil was maturing.

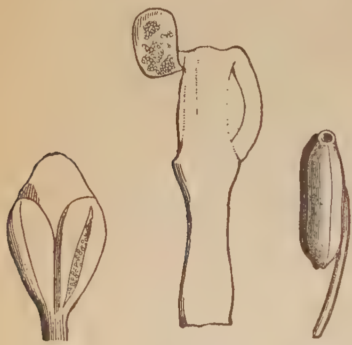


FIG. 138. — Modes of Discharging Pollen.

I, by longitudinal slits in the anther-cells (pine); II, by uplifted valves (barberry); III, by a pore at the top of each anther-lobe (rhododendron).

189. *The Anther and its Contents.* — Some of the shapes of the anthers may be learned from Figs. 116, 129, 136, 138 and 155.[1] The shape of the anther and the way in which it opens depend largely upon the way in which the pollen is to be dis-

[1] See Kerner and Oliver, vol. II, pp. 86–95.

charged and how it is carried from flower to flower. The commonest method is to have the anther-cells split lengthwise, as in Fig. 138, I. A few anthers open by trap-doors like valves, as in II, and a larger number by little holes at the top, as in III.

The pollen, in many plants with inconspicuous flowers, as the evergreen cone-bearing trees, the grasses, rushes, and sedges, is a fine, dry powder. In plants with showy flowers it is often somewhat sticky or pasty. The forms of pollen-grains are extremely various. That of the tulip (Fig. 116), and the kinds shown in Fig. 139 will serve as examples of some of the shapes which the grains assume; IV in the latter figure is perhaps as common a form as any. Each pollen-grain consists mainly of a single cell, and is covered by a moderately thick outer wall and a thin inner one. Its contents is a thickish protoplasm, full of little opaque particles and usually containing grains of starch and little drops of oil. The larger knobs on the outer coat, as at *k* (Fig. 139, I and II), mark the spots at which the inner coat of the grain is finally to burst through the outer one, pushing its way out in the form of a slender, thin-walled tube.[1]

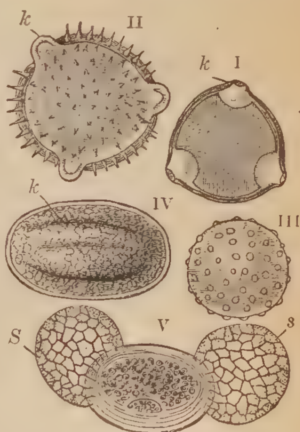


FIG. 139. — Pollen-Grains. I, hazel; II, coltsfoot; III, wild ginger; IV, hepatica; V, pine; *s s*, air-sacs. (All magnified 300 diameters.)

190. ***Experiment 32.*** *Production of Pollen Tubes.* — Place a few drops of suitably diluted syrup[2] with some fresh pollen in a concave cell ground in a microscope slide; cover with thin glass circle; place under

[1] See Kerner and Oliver, vol. II, pp. 95–104. [2] See Appendix B.

a bell glass, with a wet cloth or sponge, to prevent evaporation of the syrup, and set aside in a warm place, or merely put some pollen in syrup in a watch crystal under the bell glass. Examine from time to time to note the appearance of the pollen tubes. Try several kinds of pollen if possible, using syrups of various strengths. The following kinds of pollen form tubes readily in syrups of the strengths indicated :

Tulip	1 to 3	per cent.
Narcissus	3 to 5	"
Cytisus Canariensis (called Genista by florists)	15	"
Chinese primrose	10	"
Sweet pea[1]	10 to 15	"
Tropæolum[1]	15	"

FIG. 140. — Stigma of Thorn Apple (Datura) with Pollen (magnified).

FIG. 141. — Part of Stigma of Thorn Apple. Vertical section (magnified), showing pollen tubes making their way toward the ovary.

191. *Microscopical Structure of the Stigma and Style.* — Under a moderate power of the microscope the stigma is seen to consist of cells arranged rather loosely over the surface, and secreting a moist liquid to which the pollen-grains adhere (Fig. 140). Beneath these superficial cells and running down

[1] The sweet pea pollen and that of Tropæolum are easier to manage than any other kinds of which the author has personal knowledge. If a concaved slide is not available, the cover-glass may be propped up on bits of the thinnest broken cover-glasses. From presence of air or some other reason, the formation of pollen tubes often proceeds most rapidly just inside the margin of the cover-glass.

through the style (if there is one), there are found long cells sometimes with intermediate spaces, through which latter the pollen tubes readily find their way (Fig. 141). When no such intercellular spaces exist, the pollen tube proceeds through the cell walls, which it softens by means of a substance which it exudes for that purpose.

192. *Structure of the Ovule.* — The details of the microscopic anatomy of the ovule are rather complicated. It is enough for our present purpose to state that the young ovule, before it has begun to form an embryo, usually exists as a roundish or egg-shaped mass, with a small opening leading into its apex. This opening leads to a sac inside the ovule, filled with soft protoplasmic material, containing cells and known as the *embryo sac.* Minute cells occur at the apex of the ovule (Fig. 142), and it is from their growth and development that the embryo is at length produced.

CHAPTER XVIII.

Fertilization; Transfer of Pollen, Protection of Pollen.

193. *Fertilization.* — By fertilization in flowering plants the botanist means the union of a nucleus from a pollen-grain with that of a cell at the apex of the *embryo sac* (Fig. 142). This process gives rise to a cell which contains material derived from the pollen and from the ovule cell. In a great many plants the pollen, in order to accomplish the most successful fertilization, must come from another plant of the same kind, not from the individual which bears the ovules that are being fertilized.

Pollen tubes begin to form soon after pollen-grains lodge on the stigma. The time required for the process to begin varies in different kinds of plants, requiring in many cases twenty-four hours or more. The length of time needed for the pollen tube to make its way through the style to the ovary depends upon the length of the style and other conditions. In the crocus, which has a style several inches long, the descent takes from one to three days.

Finally the tube penetrates the opening at the apex of the ovule *m*, in Fig. 142, reaches one of the cells shown at *e*, and transfers a nucleus into this egg-cell. The latter is thus enabled to divide and grow rapidly into an embryo. This the cell does by forming cell walls and then increasing by continued subdivision in much the same way in which the cells at the growing point near the tip of the root, or those of the cambium layer subdivide.[1]

194. *Nature of the Fertilizing Process.* — The necessary feature of the process of fertilization is *the union of the essential contents of two cells to form a new one, from which the*

[1] See Kerner and Oliver, vol. II, pp. 401–420.

future plant is to spring. This kind of union is found to occur in many flowerless plants (Chapter XXIII), resulting in the production of a spore very unlike a seed in most respects, but capable of growing into a complete plant like that which produced it.

195. *Number of Pollen Grains to each Ovule.*— Only one pollen tube is necessary to fertilize each ovule, but so many pollen-grains are lost that plants produce many more of them than of ovules. The ratio, however, varies greatly. In the night-blooming cereus there are about 250,000 pollen-grains for 30.000 ovules, or rather more than 8 to 1, while in the common garden wistaria there are about 7,000 pollen grains to every ovule, and in Indian corn, the cone-bearing evergreens, and a multitude of other plants, many times more than 7.000 to 1. These differences depend. as will be seen presently. upon the mode in which the pollen is carried from the stamens to the pistil.

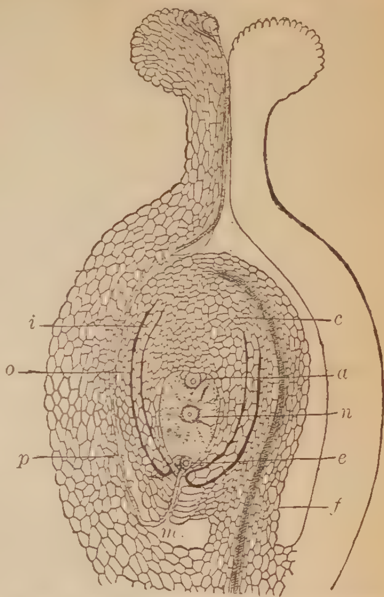


FIG. 142. — Diagrammatic Representation of Fertilization of an Ovule.

i, inner coating of ovule; *o*, outer coating of ovule; *p*, pollen tube, proceeding from one of the pollen-grains on the stigma; *c*, the place where the two coats of the ovule blend (The kind of ovule here shown is inverted, its opening *m* being at the bottom, and the stalk *f* adhering along one side of the ovule.) *a* to *e*, embryo sac, full of protoplasm; *a*, so-called antipodal cells of embryo sac; *n*, central nucleus of the embryo sac; *e*, nucleated cells, one of which receives the essential contents of the pollen tube: *f*, funiculus or stalk of ovule; *m*, opening into the ovule.

196. *Cross-Fertilization and Self-Fertilization.* — It was long supposed by botanists that the pollen of any perfect flower needed only to be placed on the stigma of the same flower to insure satisfactory fertilization. But in 1857 and 1858 the great English naturalist, Charles Darwin, stated that certain kinds of flowers were entirely dependent for fertilization on the transference of pollen from one plant to another, and he and other botanists soon extended the list of such flowers until it came to include most of the showy, sweet-scented or otherwise conspicuous kinds. It was also shown that probably nearly all attractive flowers, even if they can produce some seed when self-fertilized, do far better when fertilized with pollen from the flowers of another plant.[1] This important fact was established by a long series of experiments on the number and vitality of seeds produced by a flower when treated with its own pollen, or *self-fertilized*, and when treated with pollen from another flower of the same kind, or *cross-fertilized*.[2]

197. *Wind-Fertilized Flowers.*[3] — It has already been mentioned (§ 189), that some pollen is dry and powdery, and other kinds are more or less sticky. Pollen of the dusty sort is light, and therefore adapted to be blown about by the wind. Any one who has been much in cornfields after the corn has "tasseled" has noticed the pale yellow dusty pollen which flies about when a cornstalk is jostled, and which collects in considerable quantities on the blades of the leaves. Corn is monœcious, but fertilization is best accomplished by pollen blown from the "tassel" (stamens) of one plant being carried to the "silk" (pistils) of another plant. This is well shown by the fact, familiar to every observing farmer's boy, that solitary cornstalks, such as often grow very luxuriantly in an unused barnyard or similar locality, bear very imperfect

[1] See Darwin's *Cross and Self-Fertilization in the Vegetable Kingdom* (especially Chapters I and II).

[2] On dispersion of pollen see Kerner and Oliver, vol. II, 129–287.

[3] See Miss Newell's *Botany Reader*, Part II, Chapter VII.

ears or none at all. The common ragweed, another monœcious plant, is remarkable for the great quantities of pollen which shake off it on to the shoes or clothes of the passer-by, and it is wind-fertilized. So, too, are the monœcious pines, and these produce so much pollen that it has been mistaken for showers of sulphur, falling often at long distances from the woods where it was produced. The pistil of wind-fertilized flowers is often feathery and thus adapted to catch flying pollen-grains (Fig. 143). Other characteristics of such flowers are the inconspicuous character of their flowers, which are usually green or greenish, the absence of odor and of nectar, the regularity of the corolla, and the appearance of the flowers before the leaves or their occurrence on stalks raised above the leaves.

FIG. 143.—Pistil of a Grass.

a, ovary; *b*, feathery stigma, adapted for wind-fertilization.

Pollen is, in the case of a few aquatic plants, carried from flower to flower by the water on which it floats.

198. *Insect-Fertilized Flowers.*—Most plants which require cross-fertilization depend upon insects as pollen-carriers,[1] and it may be stated as a general fact that the showy colors and markings of flowers and their odors, all serve as so many advertisements of the nectar (commonly but wrongly called honey), or of the nourishing pollen which the flower has to offer to insect-visitors.

Many insects depend mainly or wholly upon the nectar and the pollen of flowers for their food. Such insects usually visit during the day only one kind of flower, and therefore carry but one kind of pollen. Going straight from one flower to another with this, they evidently waste far less pollen than the wind or water must waste. It is therefore clearly advantageous to flowers to develop such adaptations as fit

[1] A few are fertilized by snails; many more by humming-birds and other birds.

them to attract insect-visitors, and to give pollen to the latter and receive it from them.

199. *Pollen-Carrying Apparatus of Insects.*[1] — Ants and many beetles which visit flowers have smooth bodies, to which little pollen adheres, so that their visits are often of little value to the flower, but many beetles, all butterflies and moths and most bees have bodies roughened with scales or hairs so as to hold a good deal of pollen entangled. In the common honey-bee (and in many other kinds) the greater part of the insect is hairy, and there are special collecting baskets, formed by bristle-like hairs, on the hind-legs, Fig. 144. It is easy to see the load of pollen accumulated in these baskets, after such a bee has visited several flowers. Of course the pollen which the bee packs in the baskets and carries off to the hive, to be stored for food, is of no use in fertilization. In fact such pollen is in one sense entirely wasted. But since such bees as have these collecting baskets are the most industrious visitors to flowers, they accomplish an immense share of the work of fertilization by means of the pollen-grains which stick to their hairy coats.

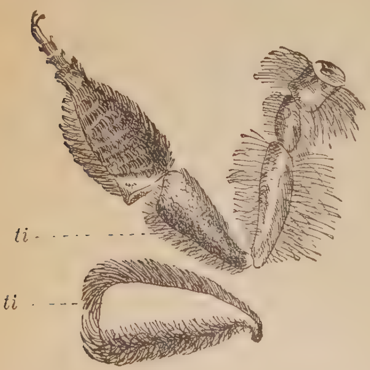


FIG. 144. — Right Hind-Leg of a Honey-Bee. (Seen from behind and within.)
ti (below), the tibia seen from the outside, showing the collecting basket, formed of stiff hairs.

200. *Nectar and Nectaries.* — Nectar is a sweet liquid which flowers secrete for the purpose of attracting insects. After partial digestion in the crop of the bee, nectar becomes

[1] See Müller's *Fertilization of Flowers*, Part II.

honey. Those flowers which secrete nectar do so by means of *nectar-glands*, small organs whose structure is something like that of the stigma, situated usually near the base of the flower, as shown in Fig. 145. Sometimes the nectar clings in droplets to the surface of the nectar-glands; sometimes it is stored in little cavities or pouches called *nectaries*. The pouches at the bases of columbine petals are among the most familiar of nectaries.

201. *Odors of Flowers.* — The acuteness of the sense of smell among insects is a familiar fact. Flies buzz about the wire netting which covers a piece of fresh meat or a dish of syrup, and bees, wasps, and hornets will fairly besiege the window-screens of a kitchen where preserving is going on. Many plants find it possible to attract as many insect-visitors as they need without giving off any scent, but small flowers, like the mignonette, and night-blooming ones, like the four-o'-clock and the evening primrose, are sweet-scented to attract night-flying moths. It is interesting to observe that the majority of the flowers which bloom at night are white, and that they are much more generally sweet-scented than flowers which bloom during the day. A few flowers are carrion-scented (and purplish or brownish colored) to attract flies.

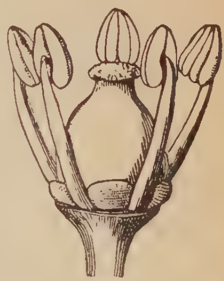


FIG. 145. — Stamens and Pistil of the Grape (magnified), with a nectar-gland between each pair of stamens.

202. *Colors of Flowers.* — Flowers which are of any other color than green display their colors to attract insects, or occasionally birds. The principal color of the flower is most frequently due to showy petals, sometimes, as in the marsh marigold, it belongs to the sepals, and not infrequently, as in some cornels and Euphorbias, the involucre is more brilliant and conspicuous than any part of the flower strictly so-called.

Different kinds of insects are especially attracted by different colors. In general, dull yellow, brownish or dark purple flowers, especially if small, seem to depend largely on the visits of flies. Red, violet, and blue are the colors by which bees and butterflies are most readily enticed. The power of bees to distinguish colors has been shown by a most interesting set of experiments in which daubs of honey were put on slips of glass laid on separate pieces of paper, each of a different color, and exposed where bees would find them.[1]

203. *Nectar Guides.* — In a large number of cases the petals of flowers show decided stripes or rows of spots, of a color different from that of most of the petal. These commonly lead toward the nectaries, and there is no doubt that such markings point out to insect-visitors the way to the nectaries. Following this course, the insect not only secures the nectar which he seeks, but perhaps leaves pollen on the stigma and becomes dusted with new pollen which he carries to another flower.

204. *Facilities for Insect Visits.* — Regular polypetalous flowers have no special adaptations to make them singly accessible to insects, but lie open to all comers. They do, however, make themselves much more attractive and afford especial inducements in the matter of saving time to flower-frequenting insects by being grouped. This purpose is undoubtedly served by dense flower-clusters, especially by heads like those of the clovers and by the peculiar form of head found in so-called compound flowers, like the sunflower and the bachelor's button (Fig. 165). In many such clusters the flowers are specialized, some as in Fig. 110, carrying a showy strap-shaped corolla, to serve as an advertisement of the nectar and pollen contained in the inconspicuous tubular

[1] See Lubbock's *Flowers, Fruits, and Leaves*, Chapter I. On the general subject of colors and odors in relation to insects, see Müller's *Fertilization of Flowers*, Part IV.

flowers. Irregular flowers probably always are more or less adapted to particular insect (or other) visitors. The adaptations are so numerous that many volumes could be filled with a description of them;—here only a very few of the simpler ones will be pointed out. Where there is a drooping lower petal (or, in the case of a gamopetalous corolla, a lower lip), this serves as a perch upon which flying insects may alight and stand while they explore the flower, as the beetle is doing in Fig. 146. In Fig. 147 one bumble-bee stands with his legs partially encircling the lower lip of the dead nettle flower, while another perches on the sort of grating made by the stamens of the horse-chestnut flower. The honey-bee entering the violet clings to the beautifully bearded portion of the two lateral petals, while it sucks the nectar from the *spur* beneath.

FIG. 146. — A Beetle on the Flower of the Twayblade. (Enlarged four times.)

FIG. 147. — Bees visiting Flowers.

At the left a bumble-bee (European) on the flower of the dead nettle; above a similar bee in the flower of the horse-chestnut; below. a honey-bee in the flower of a violet.

205. *Protection of Pollen from Unwelcome Visitors.* — It is usually desirable for the flower to prevent the entrance of small creeping insects, such as ants, which carry little pollen and eat a relatively large amount of it. The means adopted to secure this result are many and curious. In some plants, as the common catchfly, there is a sticky ring about the peduncle, some distance below the flowers, and this forms an effectual barrier against ants and like insects. Very frequently the calyx-tube is covered with hairs, which are sometimes sticky, as in Fig. 148, I, II, and VII. How these thickets of hairs may appear to a very small insect can perhaps be more easily realized by looking at the considerably magnified view of the hairs from the outer surface of mullein petals, shown in Fig. 149.[1]

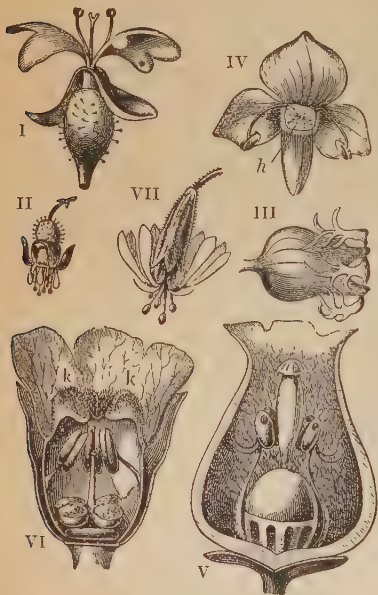


FIG. 148. — Flowers protected from Unwelcome Visitors.

I, enchanter's nightshade, magnified five times; II, gooseberry, natural size; III, tellima, magnified two times; IV, speedwell, magnified four times; V, bearberry, magnified six times; VI, hound's-tongue, magnified four times; VII, nodding campion, natural size, at midnight.

Sometimes the recurved petals or divisions of the corolla stand in the way of creeping insects, as in III and VII. In other cases the throat of the corolla is much narrowed, as in V, or closed

[1] On protection of pollen see Kerner and Oliver, vol. II, pp. 95–109.

by hairs, *h* in IV, or by appendages, *k* in VI. Those flowers which have one or more sepals or petals prolonged into spurs, like the nasturtium and the columbine, are inaccessible to most insects except those which have a tongue, or a sucking-

FIG. 149. — Branching Hairs from the Outside of the Corolla of the Common Mullein (magnified).
dr, a gland.

tube long enough to reach to the nectary at the bottom of the spur. The large sphinx moth, shown in Fig. 150, which is a common visitor to the flowers of the evening primrose, is an

FIG. 150. — A Sphinx Moth, with a Long Sucking-Tube.

example of an insect especially adapted to reach deep into long tubular flowers.

A little search among flowers, such as those of the columbine or the foxglove, will usually disclose many which have had the corolla bitten through by bees, which are unable to get at the nectar by fair means and so steal it.

206. *Bird-Fertilized Flowers.* — Some flowers with very long tubular corollas depend entirely upon birds to carry their pollen for them. Among garden flowers the gladiolus, the scarlet salvia and the trumpet honeysuckle are largely dependent upon humming-birds for their fertilization. The

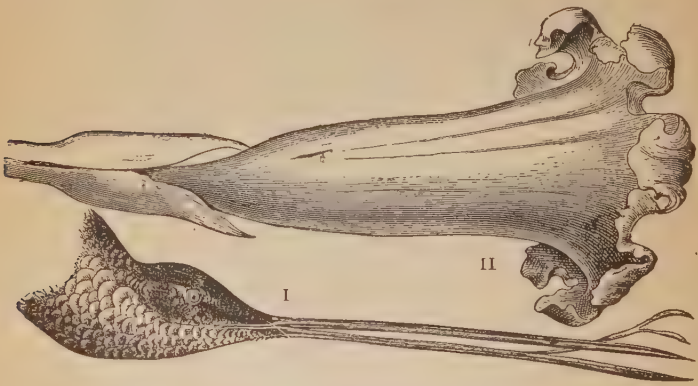


FIG. 151. — Flower-Frequenting Bird, with a Flower.
I, head of a sword-beak ; II, a datura flower, visited by it. (Both two-thirds natural size.)

wild balsam or jewel-weed and the trumpet-creeper are also favorite flowers of the humming-bird. In Fig. 151 the head of a flower-visiting bird and a flower frequented by it are shown.

207. *Prevention of Self-Fertilization.* — Diœcious flowers are of course quite incapable of self-fertilization. Pistillate monœcious flowers may be fertilized by staminate ones on the same plant, but this does not secure so good seed as is secured by having pollen brought to the pistil from a different plant.

In perfect flowers self-fertilization would commonly occur unless it were prevented by the action of the essential organs or by something in the structure of the flower. In reality flowers which at first sight would appear to be designed to secure self-fertilization are almost or quite incapable of it. Frequently the pollen from another plant prevails over that which the flower may shed on its own pistil, so that when both kinds are placed on the stigma at the same time it is the foreign pollen which causes fertilization. But apart from this fact, there are several means of insuring the presence of foreign pollen, and only that, upon the stigma, just when it is mature enough to receive pollen tubes.

FIG. 152. — Flower of Clerodendron in Two Stages.

In the upper figure (earlier stage) the stamens are mature, while the pistil is still undeveloped and bent to one side. In the lower figure (later stage) the stamens have withered and the stigmas have separated, ready for the reception of pollen.

208. *Stamens and Pistils maturing at Different Times.* — If the stamens mature at a different time from the pistils, self-fertilization is as effectually prevented as though the plant were diœcious. This unequal maturing or *dichogamy* occurs in many kinds of flowers. In some, the figwort and the common plantain, for example, the pistil develops before the stamens, but usually the reverse is the case. The *Clerodendron*, a tropical African flower, illustrates in a most striking way the development of stamens before the pistil. The insect-visitor, on its way to the nectary, can hardly fail to brush against the protruding stamens of the flower in its

earlier stage (above), but it cannot deposit any pollen on the stigmas which are unripe, shut together and tucked aside, out of reach. On flying to a flower in the later stage the pollen

FIG. 153.—Provisions for Cross-Fertilization in the High Mallow.

I, essential organs as found in the bud; II, same in the staminate stage, the anthers discharging pollen, pistils immature; III, intermediate stage, *stig*, the united stigmas; IV, pistillate stage, the stigmas separated, stamens withered.

just acquired will be lodged on the prominent stigmas and thus produce the desired cross-fertilization.

FIG. 154.—Stamens and Pistils of Round-Leafed Mallow (the stigmas curled round among the stamens to admit of self-fertilization).

Closely related flowers often differ in their plan of fertilization. The high mallow, a plant cultivated for its purplish flowers, which has run wild to some extent, is admirably adapted to secure cross-fertilization with its own pollen, since when its stamens are shedding pollen, as in Fig. 153, II, the pistils are incapable of receiving it, while when the pistils are mature, as at IV, the stamens are quite withered. In the common low mallow of our door-yards and waysides, insect fertilization may occur, but if it does not the curling stigmas finally come in contact with

the projecting stamens and receive pollen from them, as is indicated in Fig. 154.

209. *Movements of Floral Organs to aid in Fertilization.*—Besides the slow movements which the stamens and pistil make in such cases as those of the *Clerodendron* and the mallow, already described, the parts of the flower often admit of considerable and rather quick movements to assist the insect-visitor to become dusted or smeared with pollen.

In some flowers whose stamens perform rapid movements when an insect enters, it is easy to see how directly useful the motion of the stamens is in securing cross-fertilization.

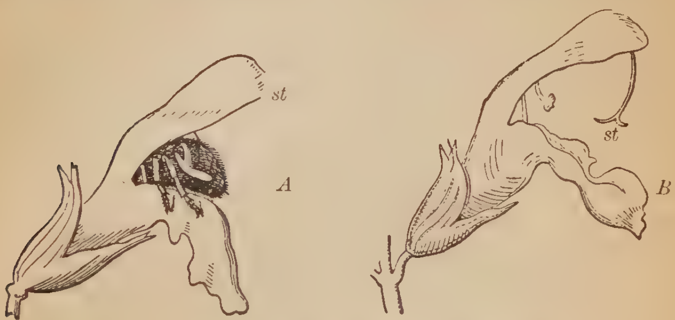


Fig. 155.—Two Flowers of Common Sage, one of them visited by a bee.

The stamens of the laurel, *Kalmia*, throw little masses of pollen, with a quick jerk, against the body of the visiting insect. Barberry stamens spring up against the visitor and dust him with pollen. The common garden sage matures its anthers earlier than its stigmas. In Fig. 155, *A*, the young flower is seen, visited by a bee, and one anther is shown pressed closely against the side of the bee's abdomen. The stigma *st* is hidden within the upper lip of the corolla. In *B*, an older flower, the anthers have withered and the stigma is now lowered so as to brush against the body of any

bee which may enter. A little study of Fig. 156 will make clear the way in which the anthers are hinged, so that a bee striking the empty or barren anther-lobes *a* knocks the pollen-

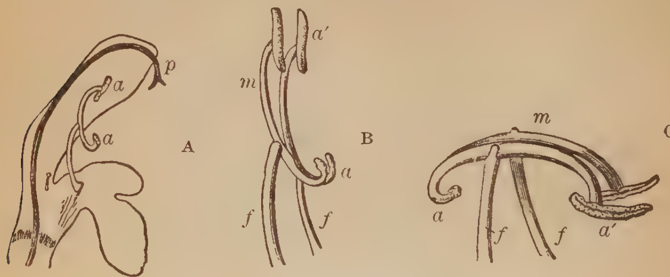


FIG. 156.—Flower and Stamens of Common Sage.

A, *p*, stigma; *a*, anthers. B, the two stamens in ordinary position; *f*, filaments; *m*, connective (joining anther-cells); *a*, *a*, anther-cells. C, the anthers and connectives bent into a horizontal position by an insect pushing against *a*.

bearing lobes *a′* into a horizontal position, so that they will lie closely pressed against either side of its abdomen.

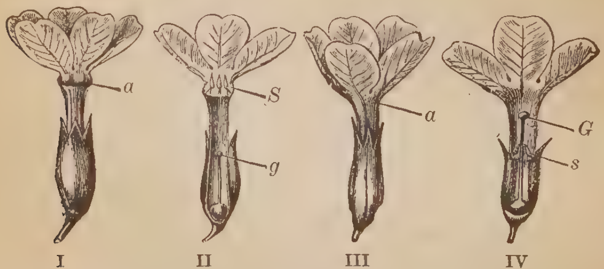


FIG. 157.—Dimorphous Flowers of the Primrose.

I, II, short-styled form; III, IV, long-styled form, natural size; *a*, throat of the corolla; *S*, *s*, stamens; *G*, *g*, styles.

210. *Flowers with Stamens and Pistils each of Two Lengths.*—The flowers of bluets, partridge-berry, the primroses and a few other common plants secure cross-fertilization by hav-

ing essential organs of two forms, Fig. 157. Such flowers are said to be *dimorphous* (*of-two-forms*). In the short-styled flowers, I, II, the anthers are borne at the top of the corolla tube *a*, *S*, and the stigma, *g*, stands about half-way up the tube. In the long-styled flowers, III, IV, the stigma *G* is at the top of the tube and the anthers, *S*, are borne about half-way up. An insect, pressing its head into the throat of the corolla of I or II would become dusted with pollen which would be brushed off on the stigma of a flower like III or IV. On leaving a long-styled flower, IV, the bee's tongue would be dusted over with pollen, some of which would necessarily be rubbed off on the stigma of the next short-styled flower that was visited. Cross-fertilization is insured, since all the flowers on a plant are of one kind, either long-styled or short-styled, and since the pollen is of two sorts, each kind sterile on the stigma of any flower of similar form to that from which it came.

Trimorphous flowers, with long, medium, and short styles, are found in a species of loosestrife.[1]

211. *Studies in Insect Fertilization.* — The student cannot gather more than a very imperfect knowledge of the details of cross-fertilization in flowers without actually watching some of them as they grow, and observing their insect-visitors. If the latter are caught and dropped into a wide-mouthed stoppered bottle containing a bit of cotton saturated with chloroform, they will be painlessly killed and most of them may be identified by any one who is familiar with our common insects. The insects may be observed and classified in a general way into butterflies, moths, bees, flies, wasps, and beetles, without being captured or molested.

Whether these out-of-door studies are made or not, several flowers should be carefully examined and described as regards their arrangements for attracting and utilizing insect-visitors (or birds). The following list includes a considerable number of the most accessible flowers of spring and early summer, about which it is easy to get information from books.

[1] See Miss Newell's *Reader in Botany*, Part II, pp. 60–63.

List of Insect-Fertilized Flowers.[1]

	I.	
1. Flax	*Linum usitatissimum*	Müll.
2. Missouri currant	*Ribes aureum*	Müll.
3. Snowberry	*Symphoricarpus racemosus*	Müll.
4. Lilac	*Syringa Persica*	Müll.
5. Periwinkle	*Vinca minor*	Müll.
6. Mignonette	*Reseda odorata*	Müll.
7. Pansy	*Viola tricolor*	Müll.
8. Dead nettle	*Lamium album*	Lubbock.
9. Bleeding heart	*Dicentra* (*Diclytra*) *spectabilis*	Müll.
10. Columbine	*Aquilegia vulgaris*	Müll.
11. Monkshood	*Aconitum Napellus*	Müll.
	II.	
12. Larkspur	*Delphinium elatum*, *D. consolida*	Müll.
13. Herb Robert	*Geranium Robertianum*	Müll.
14. Pink	*Dianthus* (various species)	Müll.
15. Fireweed	*Epilobium angustifolium*	Gray.
16. Nasturtium	*Tropæolum majus*	Newell, Lubbock
17. Lily of the valley	*Convallaria majalis*	Müll.
18. Heal-all	*Brunella* (*Prunella*) *vulgaris*	Müll.
19. Ground ivy	*Nepeta Glechoma*	Müll., Newell.
20. Lousewort	*Pedicularis Canadensis*	Müll., Newell.
21. Snapdragon	*Antirrhinum majus*	Müll.
22. Iris	*Iris versicolor*	Newell.
23. Bellflower	*Campanula rapunculoides*	Müll.
24. Horse-chestnut	*Æsculus Hippocastanum*	Newell.
	III.	
25. Yarrow	*Achillea millefolium*	Müll.
26. Ox-eye daisy	*Chrysanthemum Leucanthemum*	Müll.
27. Dandelion	*Taraxacum officinale*	Müll., Newell.

[1] The plants in this list are arranged somewhat in the order of the complexity of their adaptations for insect fertilization, the simplest first. It would be well for each student to take up the study of the arrangements for the utilization of insect-visitors in several of the groups above, numbered with Roman numerals. The teacher will find explanations of the adaptations in the works cited by abbrevia-

LIST OF INSECT-FERTILIZED FLOWERS — *concluded.*

IV.

28. Barberry	*Berberis vulgaris*	Lubbock.
29. Mountain laurel	*Kalmia latifolia*	Gray.

V.

30. White clover	*Trifolium repens*	Müll.
31. Red clover	*Trifolium pratense*	Müll.
32. Locust	*Robinia Pseudacacia*	Gray.
33. Wistaria	*Wistaria Sinensis*	Gray.
34. Vetch	*Vicia cracca*	Müll.
35. Pea	*Pisum sativum*	Müll.
36. Bean	*Phaseolus vulgaris*	Gray.
37. Ground-nut	*Apios tuberosa*	Gray.

VI.

38. Partridge-berry	*Mitchella repens*	Gray.
39. Primrose	*Primula grandiflora, P. officinalis*	Lubbock.
40. Loosestrife	*Lythrum Salicaria*	Gray.

VII.

41. Milkweed	*Asclepias Cornuti*	Müll., Newell.

VIII.

42. Lady's-slipper	*Cypripedium acaule*	Newell.

212. *Protection of Pollen from Rain.* — Pollen is very generally protected from being soaked and spoiled by rain or dew either by the natural position of the flower preventing rain from entering, as in the case with most gamopetalous, nodding flowers, or by changes in the position of the flower, and by its opening in sunny weather and closing at night or during

tions at the right. Müll. stands for Müller's *Fertilization of Flowers;* Lubbock, for *British Wild Flowers, Considered in Relation to Insects;* Gray, for Gray's *Structural Botany;* and Newell, for Miss Newell's *Outlines of Lessons in Botany,* Part II. Consult also Weed's *Ten New England Blossoms.*

rain. Sometimes the flower both changes its position and closes, as is the case with the herb Robert and the sweet scabious, Fig. 158. The adaptations of flowers to protect their pollen from being wetted can best be made out by actually examining the same flower in sunshine and during rain.

FIG. 158. — Protection of Pollen from Moisture.

I, herb Robert in sunny weather ; II, sweet scabious in sunny weather ; III, sweet scabious during rain ; IV, herb Robert during rain.

213. *Detailed Study of Flowers.* — Now that the student has learned something of the adaptations of flowers to insect-visitors, he is able to carry on such studies as those of Chapter XV in more detail. After making a careful examination of the flower as a whole and of its parts,

in various stages of maturity, he may investigate its adaptations for insect fertilization and its mode of protecting its pollen from creeping insects and from rain. It will be particularly interesting to compare the various degrees of perfection with which closely related flowers attain these results. Several flowers should be worked out pretty fully and the results of the examination of each recorded in a written account and a series of sketches. Out of the many possible studies of this kind the following are suggested:

The flower of the pea, the bean, or the locust, consulting Figs. 159, 160, 161.

FIG. 159. — Sweet Pea, Flower, Young Fruit, and Leaf.

I II III

FIG. 160. — I, Diagram of Flower of Sweet Pea. II, Vertical Section of Flower (magnified). III, Calyx (magnified).

The flower of the peach, the plum, or the rose, consulting Figs. 162 and 163.

FIG. 161. — I, Stamens and Pistil of Sweet Pea (magnified). II, Fruit. III, Part of Fruit, showing one seed.

FIG. 162. — Flower of Pear.

FIG. 163. — I, Vertical section of Flower of Pear. II, Ovary, transverse section. III, Entire Seed (magnified). IV, Seed, vertical section (magnified).

The flower of the ox-eye daisy, or the dandelion, consulting Figs, 110, 131, 164, 165, 166

FIG. 164. — Flower-Cluster of Bachelor's Button (*Centaurea Cyanus*).

The flower of the crocus, the blue-eyed grass, or the iris, consulting Figs. 167 and 168.[1]

[1] For descriptions and illustrations that will aid in the work of this section the teacher is referred to Gray's *Structural Botany*, Gray's *Field, Forest, and Garden Botany*, Le Maout and Decaisne's *Traité Général de Botanique*, and Miss Newell's *Outlines of Lessons in Botany*, Part II.

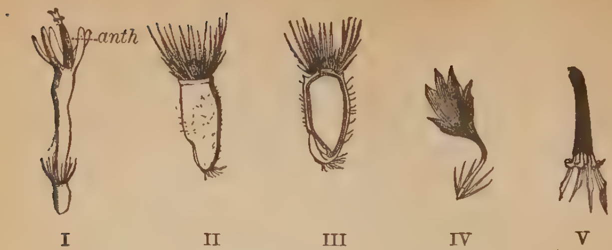


FIG. 165. — Bachelor's Button.

I, a tubular flower (magnified), *anth*, the united anthers; II, fruit (magnified); III, fruit, vertical section (magnified); IV, a neutral ray-flower;[1] V, ring of anthers.

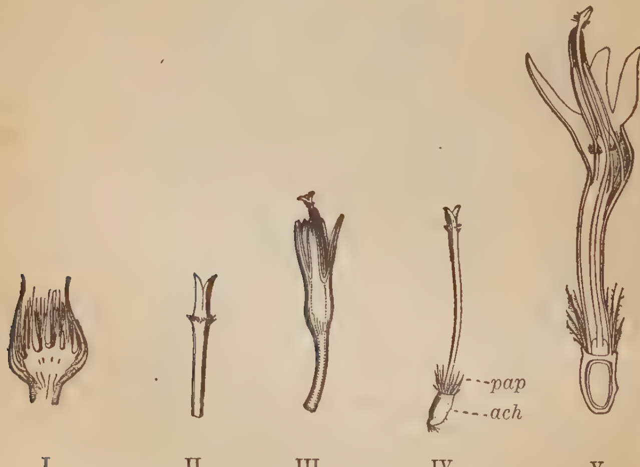


FIG. 166. — Bachelor's Button.

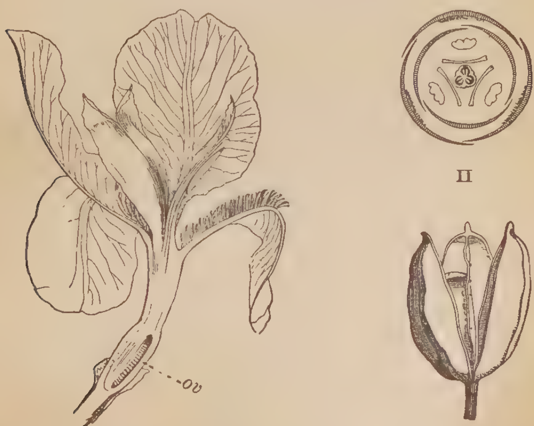
I, vertical section of the receptacle; II, style and forked stigma (magnified); III, corolla, united anthers and stigma (magnified); IV, pistil (magnified), *pap*, pappus, *ach*, achenium; V, tubular flower cut vertically (magnified), showing anther-tube, traversed by the style.

[1] This is not precisely homologous with the ray-flowers of Helianthus and most rayed Compositæ, but is an enlarged and conspicuous tubular flower.

I II III

FIG. 167. — Iris.

I, flower; II, seed, longitudinal section; III, flower with limb of perianth removed; *stig*, stigma, *ov*, ovary.



II

I FIG. 168. — Iris. III

I, flower, longitudinal section, *ov*, ovary; II, diagram, showing stigmas opposite the stamens; III, capsule, splitting between the partitions.

CHAPTER XIX.

The Study of Typical Fruits.

214. *A Berry, the Tomato.*[1] — Study the external form of the tomato, and make a sketch of it, showing the persistent calyx and peduncle.

Cut a cross-section at about the middle of the tomato. Note the thickness of the epidermis (peel off a strip) and of the wall of the ovary. Note the number, size, form, and contents of the cells of the ovary. Observe the thickness and texture of the partitions between the cells. Sketch.

Note the attachments of the seeds to the placentas and the gelatinous, slippery coating of each seed. Rub off this coating and then note the wing-like margin around the seed.

The tomato is a typical berry, but its structure presents fewer points of interest than are found in some other fruits of the same general character, so the student will do well to spend a little more time on the examination of such fruits as the orange or the lemon.

215. *A Hesperidium, the Lemon.* — Procure a large lemon which is not withered, if possible one which still shows the remains of the calyx at the base of the fruit.

Note the color, general shape, surface, remains of calyx, knob at portion formerly occupied by the stigma. Sketch the fruit about natural size. Examine the pitted surface of the rind with the magnifying-glass and sketch it. Remove the bit of stem and dried-up calyx from the base of the fruit; observe, above the calyx, the knob or *disk* on which the pistil stood. Note with the magnifying glass and count the minute whitish raised knobs at the bottom of the saucer-shaped depression left by the removal of the disk.

Make a transverse section of the lemon, not more than a fifth of the way down from the stigma end and note:

(1) The thick skin, pale yellow near the outside, white within.

(2) The more or less wedge-shaped divisions containing the juicy pulp of the fruit. These are the matured cells of the ovary; count these.

(3) The thin partitions between the cells.

[1] Fresh tomatoes, not too ripe, are to be used, or those which have been kept over from the previous summer in formalin solution. The very smallest varieties, such as are often sold for preserving, are as good for study as the larger kinds.

(4) The central column or axis of white pithy tissue.

(5) The location and attachment of any seeds that may be encountered in the section.

Make a sketch to illustrate these points, comparing it with Fig. 181.

Study the section with the magnifying glass and note the little spherical reservoirs near the outer part of the skin, which contain the oil of lemon which gives to lemon-peel its characteristic smell and taste. Cut with the razor a thin slice from the surface of the lemon-peel, some distance below the section, and at once examine the freshly cut surface with a magnifying glass to see the reservoirs, still containing oil, which, however, soon evaporates. On the cut surface of the pulp (in the original cross-section) note the tubes in which the juice is contained. These tubes are not cells, but their walls are built of cells. Cut a fresh section across the lemon, about midway of its length and sketch it, bringing out the same points which were shown in the previous one. The fact that the number of ovary cells in the fruit corresponds with the number of minute knobs in the depression at its base is due to the fact that these knobs mark the points at which fibro-vascular bundles passed from the peduncle into the cells of the fruit, carrying the sap by which the growth of the latter was maintained.

Note the toughness and thickness of the seed-coats. Taste the kernel of the seed.

Cut a very thin slice from the surface of the skin, mount in water, and examine with a medium power of the microscope. Sketch the cellular structure shown and compare it with the sketch of the corky layer of the bark of the potato tuber.

Of what use to the fruit is a corky layer in the skin? (See § 230 for further questions.)

216. *A Legume, the Bean-Pod.*[1] — Lay the pod flat on the table and make a sketch of it, about natural size. Label *stigma*, *style*, *ovary*, *calyx*, *peduncle*.

Make a longitudinal section of the pod, at right angles to the plane in which it lay as first sketched, and make a sketch of the section, showing the partially developed seeds, the cavities in which they lie, and the solid portion of the pod between each bean and the next.

Split another pod, so as to leave all the beans lying undisturbed on one-half of it and sketch that half, showing the beans lying in their

[1] Any species of bean (*Phaseolus*) will answer for this study. Specimens in the condition known at the markets as "shell-beans" would be best, but these are not obtainable in spring. Ordinary "string-beans" will do.

natural position and the *funiculus* or stalk by which each is attached to the *placenta;* compare Fig. 176.

Make a cross-section of another pod, through one of the beans, sketch the section and label the placenta (formed by the united edges of the pistil leaf), and the midrib of the pistil leaf.

Break off sections of the pod and determine, by observing where the most stringy portions are found, where the fibro-vascular bundles are most numerous.

Examine some ripe pods of the preceding year,[1] and notice where the *dehiscence*, or splitting open of the pods occurs, whether down the placental edge, *ventral suture*, the other edge, *dorsal suture*, or both.

217. *An Akene, the Fruit of Dock.* — Hold in the forceps a ripe fruit of any of the common kinds of dock,[2] and examine with the magnifying-glass. Note the three dry, veiny, membranaceous sepals by which the fruit is enclosed. On the outside of one or more of the sepals is found a tubercle or thickened appendage which looks like a little seed or grain. No use is known for this.

Of what use are the sepals, after drying up? Why do the fruits cling to the plant long after ripening?

Carefully remove the sepals and examine the fruit within them. What is its color, size, and shape? Make a sketch of it as seen with the magnifying glass. Note the three tufted stigmas, attached by slender threads to the apex of the fruit. What does their tufted shape indicate?

What evidence is there that this seed-like fruit is not really a seed?

Make a cross-section of a fruit and notice whether the wall of the ovary can be seen, distinct from the seed coats. Compare the dock-fruit in this respect with the fruit of the anemone, shown in Fig. 169. Such a fruit as either of these is called an *akene.*

[1] Which may be passed round for that purpose. They should have been saved and dried the preceding autumn.

[2] *Rumex crispus*, *R. obtusifolius*, or *R. verticillatus.* This should have been gathered and dried the preceding summer.

CHAPTER XX.

The Fruit.[1]

218. *What Constitutes a Fruit.* — It is not easy to make a short and simple definition of what botanists mean by the term *fruit.* It has very little to do with the popular use of the word. Briefly stated, the definition may be given as follows: *The fruit consists of the matured ovary, together with any intimately connected parts.* Botanically speaking, the bur of beggar's ticks, Fig. 179, the three-cornered grain of buckwheat, or such true grains as wheat and oats are as much fruits as is an apple or a peach.

The style or stigma sometimes remains as an important part of the fruit in the shape of a hook, as in the common hooked crowfoot; or in the shape of a plumed appendage, as in the virgin's bower, often called wild hops. The calyx may develop hooks, as in the agrimony or plumes, as in the thistle, the dandelion, lettuce, and many other familiar plants. In the apple, pear, and very many berries, the calyx becomes enlarged and pulpy, often constituting the main bulk of the mature fruit. The receptacle not infrequently, as in the apple, forms a more or less important part of the fruit.

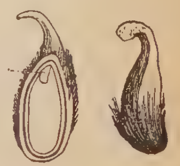


FIG. 169. — **Fruit of Wood Anemone.**

I, akene cut vertically; II, whole akene.

219. *The Akene.* — The one-celled and one-seeded pistils of the buttercup, strawberry, and many other flowers ripen into a little fruit called an akene, Fig. 169. Such fruits, from their small size, their dry consistency, and the fact that

[1] See Gray's *Structural Botany*, Chapter VII, also Kerner and Oliver, vol. II, pp. 427-438

they never open, are usually taken by those who are not botanists for seeds.

In the group of plants to which the daisy, the sunflower and the dandelion belong, the akenes consist of the ovary and the adherent calyx-tube. The limb of the calyx is borne on the summit of many akenes, sometimes in the form of teeth, sometimes as a tuft of hairs or bristles, Fig. 174.

FIG. 170. — Chestnut, a Single Fruit.

220. *The Grain.* — Grains, such as corn, wheat, oats, barley, rice and so on have the interior of the ovary completely filled by the seed, and the seed-coats and the wall of the ovary are firmly united, as shown in Fig. 9.

221. *The Nut.* — A nut, Fig. 170, is larger than an akene, usually has a harder shell and commonly contains a seed which springs from a single ovule of one cell of a compound ovary, which develops at the expense of all the other ovules. The chestnut-bur is a kind of involucre, and so is the acorn-cup. The name nut is often incorrectly applied in popular language, for example, the so-called Brazil-nut is really a large seed with a very hard testa.

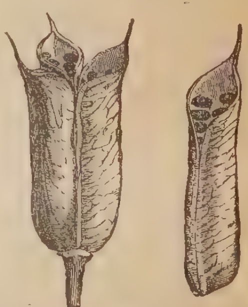


FIG. 171. — Group of Follicles and a Single Follicle of the Monkshood.

222. *Indehiscent and Dehiscent Fruits.* — All of the fruits so far considered in the present chapter are indehiscent, that is, they remain closed after ripening. Dehiscent fruits when ripe open in order to discharge their seeds. The three classes which immediately follow belong to this division.

223. *The Follicle.* — One-celled, simple pistils, like those

of the marsh marigold, the columbine, and a good many other plants, often produce a fruit which dehisces along a single suture, usually the ventral one. Such a fruit is called a *follicle*, Fig. 171.

224. *The Legume.* — A legume is a one-celled pod, formed by the maturing of a simple pistil, which dehisces along both of its sutures, as already seen in the case of the bean pod, and illustrated in Fig. 176.

225. *The Capsule.* — The dehiscent fruit formed by the

Fig. 172. — Winged Fruits.
I, elm ; II, maple.

ripening of a compound pistil is called a *capsule.* Such a fruit may be one-celled, as in the linear pod of the celandine, Fig. 176, or several-celled, as in the fruit of the poppy, the morning-glory and the Jamestown weed, Fig. 176.

226. *Dry Fruits and Fleshy Fruits.* — In all the cases discussed or described in §§ 213–219 the wall of the ovary (and the adherent calyx when present) ripen into tissues which are somewhat hard and dry. Often, however, these parts become developed into a juicy or fleshy mass by which

the seed is surrounded. Hence a general division of fruits into *dry fruits* and *fleshy fruits.*

227. *Winged or Tufted Fruits and Seeds.* — The fruits of the ash, box-elder, elm, maple, Fig. 172, and many other trees are provided with an expanded membranous wing. Some seeds, as those of the catalpa and the trumpet-creeper are similarly appendaged. The fruits of the dandelion, the thistle, the fleabane, Fig. 174, and many other plants of the group to which these belong, and the seeds of the willow, the milkweed, the willow-herb, Fig. 175, and other plants, bear a tuft of hairs, sometimes silky and in other cases plumed or feathery.

The student should be able from his own observations on the falling fruits of some of the trees and other plants above mentioned to answer some such questions as the following:

FIG. 173.—Fruit-Cluster of Linden; peduncle joined to the bract, forming a wing.

What is the use of the wing-like appendages? of the tufts of hairs?

Which set of contrivances seems to be the more successful of the two in securing this object?

What particular plant of the ones available for study seems to have attained this object most perfectly?

What is one reason why many plants with tufted seeds, such as the thistle and the dandelion, are extremely troublesome weeds?

A few simple experiments, easily devised by the student, may help him to find answers to the questions above given.[1]

[1] See Kerner and Oliver, vol. II, pp. 833-875.

It is an interesting and well-established fact that a good many birds, especially bluejays, bury large numbers of acorns and nuts which they intend to consume later, and that they leave a considerable portion of these deposits untouched. In this way large numbers of trees are annually planted.

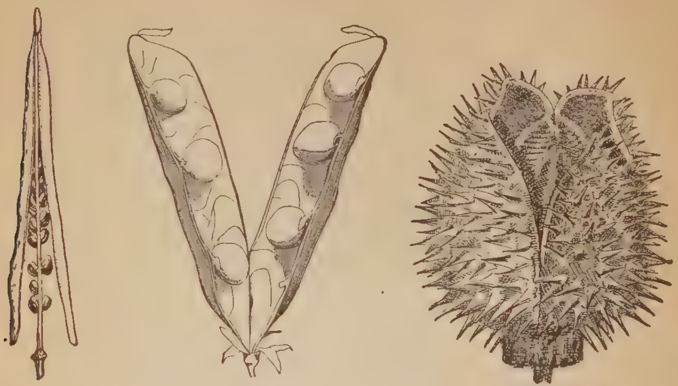
FIG. 174.—Tufted Fruit of Fleabane.

228. *Burs.* — A large class of fruits is characterized by the presence of hooks on the outer surface. These are sometimes outgrowths from the ovary, sometimes from the calyx, sometimes from an involucre. Their office is to attach the fruit to the hair or fur of passing animals or to the clothing of people who come in contact with it. Often, as in cleavers, Fig. 177, the hooks are comparatively weak, but in other cases, as in the cocklebur, Figs. 178, 179, and still more in the Martynia, the fruit of which in the green condition is

FIG. 175.—Seeds with Tufts of Hair.
I, milkweed; II, willow-herb.

much used for pickles, the hooks are exceedingly strong. Cockleburs can hardly be removed from the tails of horses and cattle, into which they have become matted, without cutting out all the hairs to which they are fastened.

The usefulness of burs to the plant which produces them is evident enough.



I II III

FIG. 176. — Dehiscent Fruits.
I, linear capsule of celandine; II, pod of pea; III, capsule of thorn-apple or Jamestown weed.

FIG. 177. — Adhesive Fruits.
At left, hound's-tongue; at right, cleavers.

Why do bur-bearing plants often carry their fruit until late winter or early spring?

What reason can be given for the fact that the burdock, the cocklebur, the beggar-ticks, the hound's-tongue, and many other common burs, are among the most persistent of weeds?

229. *Explosive Fruits.* — Some dry fruits burst open when ripe in such a way as to throw their seeds violently about. Interesting studies may be made of this section in the common blue violet, the pansy, the wild balsam, the garden balsam, the crane's-bill, the herb Robert, the witch hazel, and some other common plants. The capsule of the South American sand-box tree bursts open when thoroughly dry with a noise like that of a pistol-shot.

How are plants benefited by the explosion of the fruit?[1]

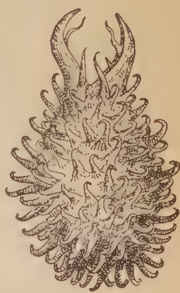


FIG. 178. — A Cocklebur, slightly enlarged.

230. *Uses of Fruits to the Plant.* — Those portions of the fruit which surround the seeds serve to enclose the ovules during their period of ripening, and to protect them from drying up or from other injuries. Other kinds of service rendered by the coatings or appendages of the fruit may have been suggested by the questions asked in some of the preceding sections.

Besides the *dry fruits* of which some of the principal kinds have been mentioned, there are many kinds of *stone fruits and fleshy fruits*, §§ 225–231. Of these the great majority are eatable by man or some of the lower animals, and oftentimes the amount of sugar and other food material which they contain is very great. It is a well recognized principle of botany, and of zoölogy as well, that plants and animals do not make outlays for the benefit of other species. Evidently the pulp of fruits is not to be consumed or used as food by the plant itself or (in general) by its seeds. It is worth

[1] See Lubbock's *Flowers, Fruits, and Leaves*, Chapter III.

while, therefore, for the student to ask himself some such questions as these:[1]

(1) Why is the pulp of so many fruits eatable?

(2) Why are the seeds of many pulpy fruits bitter or otherwise unpleasantly flavored, as in the orange?

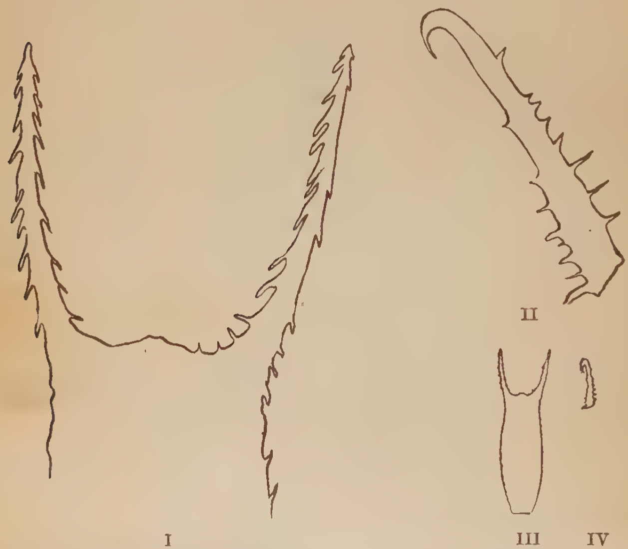


FIG. 179. — I, Barbed Points from Fruit of Beggar's Ticks, magnified eleven times. II, Hook of Cocklebur, magnified eleven times; III, Beggar's Ticks Fruit, natural size; IV, Cocklebur Hook, natural size.

(3) Why are the seeds or the layers surrounding the seeds of many pulpy fruits too hard to be chewed, as in the date and the peach?

(4) Why are the seeds of some pulpy fruits too small to be easily chewed, as in the fig and the currant?

(5) Account for the not infrequent presence of currant

[1] See Kerner and Oliver, vol. II, pp. 442–450, and *Phytobiology* (second paper), by Prof. W. F. Ganong, Bulletin No. 13 of the New Brunswick Natural History Society, St. John, N. B.

bushes or asparagus plants in such localities as the forks of large trees, sometimes at a height of twenty, thirty or more feet above the ground.

Careful observation of the neighborhood of peach, plum, cherry, or apple trees at the season when the fruit is ripe and again during the following spring, and an examination into the distribution of wild apple or pear trees in pastures where they occur, will help the student who can make such observations to answer the preceding questions. So, too, would an examination of the habits of fruit-eating quadrupeds and of the crop and gizzard of fruit-eating birds during the season when the fruits upon which they feed are ripe.

231. *The Stone-Fruit.* — In the peach, apricot, plum, and cherry, the *pericarp* or wall of the ovary, during the process of ripening, becomes converted into two kinds of tissue, the outer portion pulpy and edible, the inner portion of almost stony hardness. In common language the hardened inner layer of the pericarp, enclosing the seed, is called the "stone," Fig. 180, hence the name *stone-fruits*.

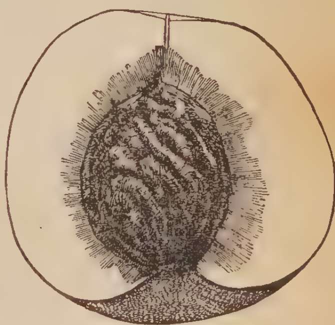


FIG. 180. — Peach. Longitudinal section of fruit.

232. *The Pome.* — The fruit of the apple, pear, and quince is called a *pome*. It consists of a several-celled ovary — the seeds and the tough membrane surrounding them in the "core," — enclosed by a fleshy, eatable portion which makes up the main bulk of the fruit and is formed from the much thickened calyx, with sometimes an enlarged receptacle.

233. *The Pepo or Gourd-Fruit.* — In the squash, pumpkin, melon, and cucumber, the ripened ovary together with the

thickened adherent calyx makes up a peculiar fruit (with a firm outer rind) known as the *pepo*. The relative bulk of enlarged calyx and of ovary in such fruits is not always the same.

How does the amount of material derived from fleshy and thickened placentæ in the squash compare with that in the watermelon?

234. *The Berry.* — The berry proper, such as the tomato, grape, persimmon, gooseberry, currant, and so on, consists of a rather thin-skinned one to several-celled fleshy ovary and its contents. In the first three cases above mentioned the calyx forms no part of the fruit, but it does in the last two, and in a great number of berries.

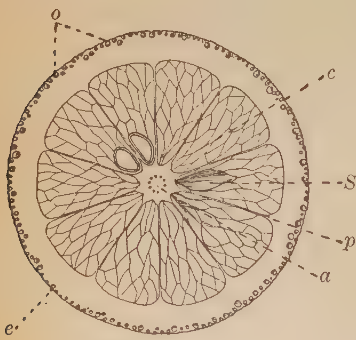


FIG. 181. — Cross-Section of an Orange.
a, axis of fruit with dots showing cut-off ends of fibro-vascular bundles; *p*, partition between cells of ovary; *S*, seed; *c*, cell of ovary, filled with a pulp composed of irregular tubes, full of juice; *o*, oil reservoirs near outer surface of rind; *e*, corky layer of epidermis.

The gourd-fruit and the *hesperidium*, such as the orange, Fig. 181, lemon, and lime, are merely decided modifications of the berry proper.

235. *Aggregate Fruits.* — The raspberry, blackberry, Fig. 182, and similar fruits consist of many carpels, each of which ripens into a part of a compound mass, which, for a time at least, clings to the receptacle. The whole is called an *aggregate fruit.*

To which one of the preceding classes does each unit of a blackberry or of a raspberry belong?

What is the most important difference in structure between a fully ripened raspberry and a blackberry?

236. *Accessory Fruits and Multiple Fruits.* — Not infrequently, as in the strawberry, Fig. 182, the main bulk of the fruit consists neither of the ripened ovary nor its appendages.

Examine with a magnifying glass the surface of a small, unripe strawberry,[1] then that of a ripe one, and finally a section of a ripe one, and decide where the separate fruits of the strawberry are found, what kind of fruits they are, and of what the main bulk of the strawberry consists.

I II III

FIG. 182. — I, Strawberry; II, Raspberry; III, Mulberry.

The fruits of two or more separate flowers may blend into a single mass, which is known as a *multiple fruit*. Perhaps the best known edible examples of this are the mulberry, Fig. 182, and the pineapple. The last-named fruit is an excellent instance of the seedless condition which not infrequently results from long-continued cultivation.

237. *Summary.* — The student may find it easier to retain what knowledge he has gained in regard to fruits if he copies the following synopsis of the classification of fruits,[2] gives an example of each kind, and in every case where it is possible to do so indicates briefly how the dispersion of the seed is secured.

[1] A few such berries, preserved in alcohol, or in formalin solution, will answer for an entire division.

[2] Suggested by Mr. Marcus L. Glazer.

Fruits	Composition	Simple.	
		Aggregate.	
		Accessory.	
		Multiple.	
	Texture	Fleshy	Berry.
			Pepo.
			Pome.
		Stone	Drupe, etc.
		Dry	Akene.
			Grain.
			Nut.
			Others.
	Mode of Disseminating Seed	Indehiscent	Akene.
			Grain.
			Nut.
		Dehiscent	Follicle.
			Legume.
			Capsule.

CHAPTER XXI.

The Struggle for Existence and the Survival of the Fittest.[1]

238. *Weeds.* — Any flowering plant which is troublesome to the farmer or gardener is commonly known as a weed. Though such plants are so annoying, from their tendency to crowd out others useful to man, they are of extreme interest to the botanist on account of this very hardiness. The principal characteristics of the most successful weeds are their ability to live in a variety of soils and exposures, their rapid growth, resistance to frost, drought, and dust, their unfitness for the food of most of the larger animals, in many cases their capacity to accomplish self-fertilization, in default of cross-fertilization, and their ability to produce many seeds and to secure their wide dispersal. Not every weed combines all of these characteristics. For instance, the velvet-leaf or butter-print[2] common in corn-fields, is very easily destroyed by frost; the pigweed and purslane are greedily eaten by pigs and the ragweed by some horses. The horse-radish does not usually produce any seeds.

It is a curious fact that many plants which have finally proved to be noxious weeds have been purposely introduced into the country. The fuller's teasel, melilot, horseradish, wild carrot, wild parsnip, tansy, ox-eye daisy, and field-garlic are only a few of the many examples of very troublesome weeds which were at first planted for use or for ornament.

[1] See Darwin's *Origin of Species*, Chapters III and IV.

[2] *Abutilon Avicennæ.*

239. *Study of Weeds.* — Select two or more out of the following list of weeds and report on the qualities which make them troublesome from the farmer's point of view (successful from their own).[1]

LIST OF WEEDS.[2]

1. Beggar's lice.*
2. Beggar's ticks.
3. Burdock.*
4. Buttercup.*
5. Butterweed.
6. Cocklebur.*
7. Charlock.*
8. Chicory.*
9. Chickweed.
10. Daisy, ox-eye.*
11. Dandelion.*
12. Dock.
13. Dog fennel.*
14. Fox-tail grass.*
15. Horse-nettle.
16. Jamestown weed.*
17. Mallow.*
18. Milkweed.
19. Nettle.
20. Pigweed.*
21. Plantain.*
22. Pokeberry.
23. Purslane.
24. Quick-grass.*
25. Ragweed.
26. Sandbur.
27. Smartweed.
28. Tansy.*
29. Thistle.*
30. Yarrow.

[1] This study will be of little value in city schools, since the plants should be examined as they grow. Specimens of the mature weed and of its fruits and seeds may be preserved by the teacher from one season to another for class use. Whole specimens of small plants, such as purslane, may be put into preservative fluid (Appendix). Ordinary weeds, such as ragweed, pigweed, etc., may be pressed and kept as roughly prepared herbarium specimens, while such very large plants as Jamestown weed, dock, etc., may be hung up by the roots and thus dried.

[2] The botanical names, as found in the last edition of Gray's Manual, are given below. Names marked in the list thus * are those of plants introduced from other countries, mostly from Europe.

1. Cynoglossum officinale.
2. Desmodium Canadense; Bidens frondosa.
3. Arctium Lappa.
4. Ranunculus bulbosus.
5. Erigeron Canadensis.
6. Xanthium spinosum.
7. Brassica Sinapistrum.
8. Cichorium Intybus.
9. Stellaria media.
10. Chrysanthemum leucanthemum.
11. Taraxacum officinale.
12. Rumex crispus.
13. Anthemis Cotula.
14. Setaria glauca.
15. Solanum Carolinense.
16. Datura Stramonium.
17. Malva rotundifolia.
18. Asclepias Cornuti.
19. Urtica gracilis.
20. Chenopodium album; Amarantus retroflexus.
21. Plantago major.
22. Phytolacca decandra.
23. Portulaca oleracea.
24. Agropyrum repens.
25. Ambrosia artemisiæfolia.
26. Cenchrus tribuloides.
27. Polygonum Hydropiper.
28. Tanacetum vulgare.
29. Cnicus lanceolatus; Cnicus arvensis.
30. Achillea millefolium.

240. *Origin of Weeds.*[1] — By far the larger proportion of our weeds are not native to this country. Some have been brought from South America and from Asia, but most of the *introduced* kinds come from Europe. The importation of various kinds of grain and of garden-seeds mixed with seeds of European weeds will account for the presence of many of the latter among us. Others have been brought over in the ballast of vessels. Once landed, European weeds have succeeded in establishing themselves in so many cases because they were superior in vitality and in their power of reproduction to our native plants. This may not improbably be due to the fact that the vegetation of Europe and the neighboring portions of Asia, much of it consisting from very early times of plants of comparatively treeless plains, has for ages been habituated to grow in cultivated ground and to contend with the crops which are tilled there.

241. *Plant Life maintained under Difficulties.* — Plants usually have to encounter many obstacles to their growth or even to their bare existence. For every plant which succeeds in reaching maturity and producing a crop of spores or of seeds, there are hundreds or thousands of failures. It is easy to show by calculation in the case of any particular kind of plant, how small a proportion the seeds which live must bear to those which are destroyed. The common morning-glory (Ipomœa purpurea) is only a moderately prolific plant, producing, in an ordinary soil, somewhat more than 3,000 seeds.[2] If all these seeds were planted and grew, there would, of course, be 3,000 plants the second summer, sprung from the single parent-plant. Suppose each of these plants to bear as the parent did, and so on. Then there would be:

[1] See the article "Pertinacity and Predominance of Weeds," in *Scientific Papers of Asa Gray*, selected by C. S. Sargent, vol. II, pp. 234–242.

[2] Rather more than 3200 by actual count and estimation.

9,000,000 plants the third year,
27,000,000,000 plants the fourth year,
81,000,000,000,000 plants the fifth year,
243,000,000,000,000,000 plants the sixth year,
729,000,000,000,000,000,000 plants the seventh year.

It is not difficult to see that the offspring of a single morning-glory plant would, at this rate, soon actually cover the entire surface of the earth. The fact that morning-glories do not occupy any larger amount of territory than they do must therefore depend upon the fact that the immense majority of their seeds are not allowed to grow into mature plants.

242. *Importance of Dispersal of Seeds.* — It is clear that any means of securing the wide distribution of seeds is of vital importance in continuing and increasing the numbers of any kind of plant, since in this way destruction by over-crowding and starvation will be lessened.

A few of the means of transportation of seeds have been hinted at in §§ 227–230, but the cases are so numerous and varied that a special treatise might well be devoted to this subject alone.

Seeds are transported by the wind, by the water, by men and other animals, and (to short distances) by the explosive action of the capsules in which they mature, or by similar contrivances. A most valuable topic for study in late summer and autumn is that of the various devices for seed-carrying found in common plants.

Not only are small seeds and fruits, like those of the willow and thistle respectively, borne for long distances by the wind, but an entire flower-cluster may ripen into a light, buoyant object, which can be blown along for many miles. Some of the so-called "tumble-weeds" of the prairies are of this description, like the tickle-grass, Fig. 183. Other tumble-weeds break off at the root, and the whole plant is

then blown along for great distances, until it is brought to a standstill by a fence or other obstacle. The Russian thistle, of which a small branch is shown in Fig. 184, forms, when growing luxuriantly, roundish bushy masses, as much as three feet high and six feet in diameter. These when dead

FIG. 183. — Partly matured Panicle of Tickle-Grass.[1]

and dry, but loaded with seeds, drift before the wind in such quantities that they often form sloping embankments reaching to the tops of high fences. One such plant has been estimated to carry with it as many as 200,000 seeds.

[1] *Panicum capillare.*

Floating on water is not, in temperate climates, as obvious and important a means of carriage as that by means of the wind, but it is often of great value, and in the case of the cocoanut, with its light fibrous husk and waterproof shell, serves to secure carriage for thousands of miles. It is inter-

FIG. 184. — Portion of a Branch of "Russian Thistle."

esting to notice that the first trees which appear on a coral island, when it emerges above water high enough to support the growth of trees at all, are cocoa palms, sprung from cocoanuts which have floated perhaps half across the South Pacific Ocean.

243. *Destruction of Plants by Unfavorable Climates.* — Land plants, throughout the greater part of the earth's surface, are killed in enormous numbers by excessive heat and drought, by floods or by frost. After a very dry spring or summer the scantiness of the crops, before the era of railroads, which nowadays enable food to be brought in rapidly from other regions, often produced actual famine. Wild plants are not observed so carefully as cultivated ones are, but almost every one has noticed the patches of grass, apparently dead, in pastures and the withered herbaceous plants everywhere through the fields and woods after a long drought.

Floods destroy the plants over large areas, by drowning them, by sweeping them bodily away, or by covering them with sand and gravel.

Frosts kill many annual plants before they have ripened their seeds, and severe and changeable winters sometimes kill perennial plants.

244. *Destruction by Other Plants.* — Overcrowding is one of the commonest ways in which plants get rid of their weaker neighbors. If the market-gardener sows his lettuce or his beets too thickly, few perfect plants will be produced, and the same kind of effect is brought about in nature on an immense scale. Sometimes plants are overshadowed and stunted or killed by the growth all about them of others of the same kind; sometimes it is plants of other kinds that crowd less hardy ones out of existence.

Whole tribes of parasitic plants, some comparatively large, like the dodder and the mistletoe, others microscopic, like blights and mildews, prey during their whole lives upon other plants.

245. *Destruction by Animals.* — All animals are supported directly or indirectly by plants. In some cases the animal secures its food without seriously injuring the plant on which it feeds. Browsing on the lower branches of a tree may do it

little injury, and grazing animals, if not very numerous, may not seriously harm the pasture on which they feed. Fruit-eating animals may even be of much service by dispersing seeds (§ 224). But seed-eating birds and quadrupeds, animals which, like the hog, dig up fleshy roots, root-stocks, tubers or bulbs, and eat them, or animals which, like the sheep, graze so closely as to expose the roots of grasses to be parched by the sun, destroy immense numbers of plants. So too with wood-boring and leaf-eating insects, and snails, which consume great quantities of leaves.

246. *Adaptations to meet Adverse Conditions.* — Since there are so many kinds of difficulties to be met before the seed can grow into a mature plant and produce seed in its turn, and since the earth's surface offers such extreme variations as regards heat, sunlight, rainfall, and quality of soil, it is evident that there is a great opportunity offered for competition among plants. Of several plants of the same kind, growing side by side, where there is room for but one full-grown one, all may be stunted, or one may develop more rapidly than the others, starve them out and shade them to death. Of two plants of different kinds the hardier will crowd out the less hardy, as ragweed, pigweed, and purslane do with ordinary garden crops. Weeds like these are rapid growers, stand drought or shade well, will bear to be trampled on, and, in general, show remarkable toughness of organization.

Plants which can live under conditions which would be fatal to most others will find much less competition than the rank and file of plants are forced to encounter. Lichens, growing on barren rocks, are thus situated, and so are the fresh-water plants, somewhat like pondscum in their structure, which are found growing in hot springs at temperatures of 140°, or in some cases up to 200°.

247. *Examples of Rapid Increase.* — Nothing but the opposition which plants encounter from overcrowding or from

the attacks of their enemies prevents any hardy kind of plant from covering all suitable portions of a whole continent, to the exclusion of most other vegetable life. New Zealand and the pampas of La Plata and Paraguay, in South America, have, during the present century, furnished wonderful examples of the spread of European species of plants over hundreds of thousands of square miles of territory. The new-comers were more vigorous, or in some way better adapted to get on in the world than the native plants which they encountered, and so managed to crowd multitudes of the latter out of existence.

In our own country, a noteworthy case of the kind has occurred so very recently that it is of especial interest to American botanists. The so-called Russian thistle,[1] Fig. 184, which is merely a variety of the saltwort, so common along the Atlantic coast, was first introduced into South Dakota in flaxseed brought from Russia and planted in 1873 or 1874. In twenty years from that time the plant had become one of the most formidable weeds known, over an area of about 25,000 square miles.

HOW PLANTS PROTECT THEMSELVES.

248. *Protection from Weather.* — Several allusions have been made in earlier chapters to the means by which plants defend themselves from excessive cold, moisture, or drought. The varnish and the woolly coating of bud-scales very likely serve the double purpose of preventing sudden changes from heat to cold, and of keeping the tender interior of the bud from becoming watersoaked.

The corky layer of the bark, whether of the stem above-ground, of the underground stem, or of the root, prevents loss of water, as was proved by Exp. 20, § 99.

The waxy coating on the under side of leaves keeps the

[1] *Salsola Kali*, var. *tragus*.

stomata from becoming clogged with water, and the hairy network on the under side of the leaf (into which they often open) may sometimes serve to prevent them from becoming clogged with dust, and certainly often hinders too rapid transpiration.

In regions where there is a long rainless season, many plants produce bulbs in which their nourishment, acquired

FIG. 185. — Arctic Willow. The greater part of a pistillate plant, about natural size.

during the growing season, is buried until the next rainy period comes round.

Desert plants are commonly fleshy and often leafless, in the latter case offering to the dry, scorching air only a small surface of green bark through which transpiration and

respiration take place. Some of the more or less spherical cacti of the dry and treeless plains of the West contain so much stored-up water that men and animals cut or tear them open for the sake of drinking from their pulpy interior.

Arctic plants are sheltered from the savage storms of winter by their habit of clinging to the ground: the Arctic willow, for example, Fig. 185, is only a few inches high.

249. *Defenses against Attacks of Animals.* — Some seeds are bitter or otherwise unpalatable, others poisonous, and still others so hard as to be utterly uneatable. The entire plant is often protected from herbivorous quadrupeds, snails, or destructive insects by the same safeguards which are found in seeds. Walking through a pasture, one may find clumps of buttercups, tansy, ragweed, boneset, dog-fennel, smartweed, or ox-eye daisy[1] which cattle and horses in general will not touch because they are so bitter, pungent, or ill-smelling. Three of the weeds that flaunt themselves most generally in barnyards in the Middle States are dog fennel, Jimpson (Jamestown) weed, and smartweed. The two former are nauseating to the smell and taste; the Jamestown weed is violently poisonous, and the smartweed has a savagely biting flavor.

Fig. 186. — Thorny Branches of Broom.

[1] These species would not all occur in any one pasture, but they are types, and some of them range widely over the country.

Beside the pasture plants above mentioned there grow such others as the bulrushes and hardhack of New England and the ironweed and vervains of the Middle States, which are so harsh and woody that the hungriest browsing animal is rarely, if ever, seen to molest them. Still other plants, like the knotgrass and cinquefoil of our dooryards, are doubly safe, from their growing so close to the ground as to be hard to graze and from their woody and unpalatable nature.

250. *The Weapons of Plants.*[1] — Multitudes of plants which might otherwise have been subject to the attacks of

FIG. 187. — Thorn Leaves of Barberry.

grazing or browsing animals, have acquired what have with reason been called weapons for defense. Shrubs and trees not infrequently produce sharp-pointed branches, like those of the broom, Fig. 186, familiar in our own crab-apple, wild plum, and above all in the honey locust, whose formidable thorns often branch in a very complicated manner.

Thorns which are really modified leaves are very perfectly exemplified in the barberry, Fig. 187. It is much commoner to find the leaf extending its midrib or its veins out into spiny points, as the thistle does, or bearing spines or prickles

[1] See Kerner and Oliver's *Natural History of Plants*, vol. I, p. 430.

on its midrib, as is the case with the nightshade shown in Fig. 88, and with so many roses. Prickles, which are merely hard, sharp-pointed projections from the epidermis, are of too common occurrence to need illustration.

Stipules are not infrequently found occurring as thorns, and in our common locust, Fig. 188, the bud, or the very young shoot, which proceeds from it, is admirably protected by the jutting thorn on either side.

Fig. 188. — Thorn Stipules of Locust.

251. *Pointed, Barbed, and Stinging Hairs.* — Needle-pointed hairs are an efficient defensive weapon of many plants. Sometimes these hairs are roughened, like those of the bugloss, Fig. 189, 6; sometimes they are decidedly barbed. In the nettle, Fig. 189, 3, the hairs are efficient stings, with a brittle tip, which on breaking off, exposes a sharp, jagged tube full of irritating fluid. These tubular hairs, with their poisonous contents, will be found sticking in considerable numbers in the skin of the hand or the face after incautious contact with nettles, and the intense itching which follows is only too familiar to most people.

252. *Cutting Leaves.* — Some grasses and sedges are generally avoided by cattle because of the sharp cutting edges of their leaves, which will readily slit the skin of one's hand if they are drawn rapidly through the fingers. Under the microscope the margins of such leaves are seen to be regularly and thickly set with sharp teeth like those of a saw, Fig. 189, 7, 8.

253. *Weapons of Desert Plants.* — In temperate regions, where vegetation is usually abundant, such moderate means of protection as have just been described are generally suffi-

cient to insure the safety of the plants which have developed them. But in desert or semi-desert regions the extreme scarcity of plant life exposes the few plants that occur there to the attacks of all the herbivorous animals that may encounter them. Accordingly, great numbers of desert

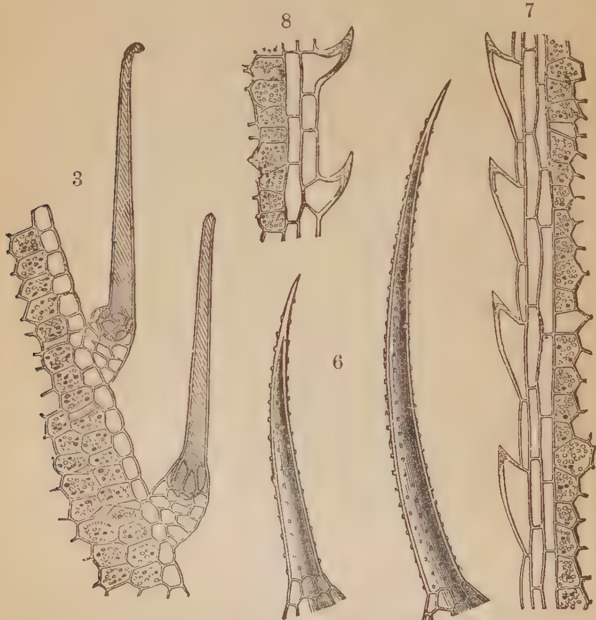


FIG. 189. — Stinging Hairs and Cutting Leaves. (All much magnified.)
3, stinging hairs on leaf of nettle; 6, bristle of the bugloss; 7, barbed margin of a leaf of sedge; 8, barbed margin of a leaf of grass.

plants are characterized by nauseating or poisonous qualities or by the presence of astonishingly developed thorns, while some combine both of these means of defense.

254. *Importance of Adaptiveness in Plants.* — It may be inferred from the preceding sections that a premium is set

on all changes in structure or habits which may enable plants to resist their living enemies or to live amid partially adverse surroundings of soil or climate. It would take a volume to state, even in a very simple way, the conclusions which naturalists have drawn from this fact of a savage competition going on among living things, and it will be enough to say here that *the existing kinds of plants to a great degree owe their structure and habits, their likenesses to each other, and their differences from each other to the operation of the struggle for existence, together with the effort to respond to changes in the conditions by which they are surrounded.* How the struggle for existence has brought about such far-reaching results will be briefly indicated in the next section.

255. *Survival of the Fittest.* — When frost, drought, blights, or other agencies kill most of the plants in any portion of the country, it is often the case that many of the plants which escape do so because they can stand more hardship than the ones which die. In this way delicate individuals are weeded out and those which are more robust survive. But other qualities besides mere toughness often decide which plant or plants of any particular kind shall live and which ones shall die out. In every grove of oaks there are some with sweeter and others with more bitter acorns. One shellbark hickory bears nuts whose shell is easily cracked by hogs, while another protects its seeds by a shell so hard that it is cracked only by a pretty heavy blow. In case of all such differences, there is a strong tendency to have the less eatable fruit or seed preserved and allowed to grow, while the more eatable varieties will be destroyed. Some individuals of the European holly produce bright red berries, while others produce comparatively inconspicuous yellow ones. It has been found that the red berries are much more promptly carried off by birds, and the seeds therefore much more widely distributed, than the yellow ones are. The result of this kind of advantage, in

any of its countless forms, is sometimes called *survival of the fittest,* and sometimes *natural selection.* The latter name means only that the outcome of the process just described, as it goes on in nature, is much the same as that of the gardener's selection, when, by picking out year by year the earliest ripening peas or certain kinds of the oddest-colored chrysanthemums, he obtains permanent new varieties. Natural agencies, acting on an enormous scale through many ages, may well be supposed to have brought about the perpetuation of millions of such variations as are known to be of constant occurrence among plants, wild as well as cultivated.

CHAPTER XXII.

The Classification of Plants.[1]

256. *Natural Groups of Plants.* — One does not need to be a botanist in order to recognize the fact that plants naturally fall into groups which resemble each other pretty closely, that these groups may be combined into larger ones the members of which are somewhat alike, and so on. For example, all the bulb-forming spring buttercups[2] which grow in a particular field may be so much alike in leaf, flower, and fruit that the differences are hardly worth mentioning. The tall summer buttercups[3] resemble each other closely but are decidedly different from the bulbous spring-flowering kind, and yet are enough like the latter to be ranked with them as buttercups. The yellow water-buttercups[4] resemble in their flowers the two kinds above mentioned but differ from them greatly in habit of growth and in foliage, while still another, a very small-flowered kind,[5] might fail to be recognized as a buttercup at all.

The marsh marigold, the hepatica, the rue anemone, and the anemone all have a family resemblance to buttercups,[6] and the various anemones by themselves form another group like that of the buttercups.

257. *Genus and Species.* — Such a group as that of the buttercups is called a *genus* (plural *genera*), while the various kinds of which it is composed are called *species.* Familiar examples of genera are the Violet genus, the Rose genus, the Clover genus, the Golden-rod genus, the Oak genus. The number of species in a genus is very various, — the Kentucky

[1] See Warming and Potter *Systematic Botany* or Kerner and Oliver, vol. II, pp. 616–790. [2] *R. bulbosus.* [3] *R. acris.* [4] *R. multifidus.* [5] *R. abortivus.*

[6] Fresh specimens or herbarium specimens will show this.

Coffee-tree genus contains only one species, while the Golden-rod genus comprises more than forty species in the north-eastern United States alone.

258. *Hybrids.* — If the pollen of a plant of one species is placed on the stigma of a plant of the same genus but a different species no fertilization will usually occur. In a large number of cases, however, the pistil will be fertilized, and the resulting seed will often produce a plant intermediate between the two parent forms. This process is called *hybridization*, and the resulting plant, a hybrid. Many hybrid oaks have been found to occur in a state of nature, and hybrid forms of grapes, orchids, and other cultivated plants are produced by horticulturists at will.

259. *Varieties.* — Oftentimes it is desirable to describe and give names to sub-divisions of species. All the cultivated kinds of apple are reckoned as belonging to one species, but it is convenient to designate such varieties as the Baldwin, the Bellflower, the Rambo, the Gravenstein, the Northern Spy, and so on. Very commonly varieties do not, as horticulturists say, "come true," that is to say, the seeds of any particular variety of apple not only are not sure to produce that variety, but they are nearly sure to produce a great number of widely different sorts. Varieties which will reproduce themselves from the seed, such as pop-corn, sweet corn, flint-corn, and so on, are called *races*.

Only long and careful study of plants themselves and of the principles of classification will enable any one to decide on the limits of the variety, species, or genus, that is, to determine what plants shall be included in a given group and what ones shall be classed elsewhere.

260. *Order or Family.* — Genera which resemble each other somewhat closely, like those discussed in § 256, are classed together in one order or family. The particular genera above mentioned, together with a large number of

others, combine to make up the Crowfoot family. In determining the classification of plants most points of structure are important, but the characteristics of the flower and fruit outrank others because they are more constant, since they vary less rapidly than the characteristics of roots, stems, and leaves do under changed conditions of soil, climate, or other surrounding circumstances. Mere size or habit of growth has nothing to do with the matter, so that the botanist finds no difficulty in recognizing the strawberry plant and the apple tree as members of the same family.

This family affords excellent illustrations of the meaning of the terms genus, species, and so on. Put in a tabular form, some of the sub-divisions of the Rose family are as follows:

The Rose family includes (among many others):

- Plum genus
  - Peach species (many varieties).
  - Garden plum species (many varieties).
  - Wild black cherry species.
  - Garden red cherry species (many varieties).
- Rose genus
  - Dwarf wild rose species.
  - Sweet-brier species.
  - India rose species
    - Tea variety.
    - Pompon variety, etc.
  - Damask rose species.
- Pear genus
  - Pear species
    - Seckel variety.
    - Bartlett variety.
    - Sheldon variety, etc.
  - Apple species
    - Baldwin variety.
    - Greening variety.
    - Bellflower variety.
    - Northern Spy variety, etc.

261. *Grouping of Families.* — Families are assembled into *classes*, and these again into larger groups. The details of the entire plan of classification are too complicated for any but professional botanists to master, but an outline of the scheme may be given in small space.

The entire vegetable kingdom is divided into two great series, the first consisting of *cryptogamous* or flowerless plants, the second of *phanerogamous* or flowering plants. Here the relations of the various subdivisions may best be shown by a table.[1]

262. *Table of the Classification of the Vegetable Kingdom.*

SERIES I. CRYPTOGAMOUS OR FLOWERLESS PLANTS	GROUP I. THALLOPHYTES, or *leafless cellular cryptogams*	Consists of about ten classes, among the most familiar members of which are the seaweeds, yeasts, mildews, moulds, toadstools, lichens, etc.
	GROUP II. BRYOPHYTES, cr *moss-like plants*	Consists of two classes, the liverworts and the mosses.
	GROUP III. PTERIDOPHYTES, or *fern-like plants.*	Consists of three classes, the ferns, the horsetails, and the lycopodiums.
SERIES II. PHANEROGAMOUS OR FLOWERING PLANTS[2]	CLASS I. GYMNOSPERMS, or conebearers, such as pines, spruces, cedars, and many other evergreen trees.	
	CLASS II. ANGIOSPERMS, or *ordinary flowering plants.*	SUB-CLASS I. MONOCOTYLEDONOUS PLANTS. SUB-CLASS II. DICOTYLEDONOUS PLANTS.

[1] This is, of course, only for consultation, and not to be committed to memory by the student.

[2] The teacher will notice that this table is carried out a little more in detail than that of Series I, since its subject-matter is more familiar and the number of classes of phanerogams is so much smaller than that of cryptogams.

263. *Plants form an Ascending Series.* — All modern systems of classification group plants in such a way as to show a succession of steps, often irregular and broken, seldom leading straight upward, from very simple forms to highly complex ones. The humblest thallophytes are merely single cells, usually of microscopic size. Class after class shows an increase in complexity of structure and of function until the most perfectly organized plants are met with among the dicotyledonous angiosperms. During the latter half of the present century it first became evident to botanists that among plants *deep-seated resemblances imply actual relationship, the plants which resemble each other most are most closely akin by descent, and (if it were not for the fact that countless forms of plant life have wholly disappeared) the whole vegetable kingdom might have the relationships of its members worked out by a sufficiently careful study of the life histories of individual plants and the likenesses and differences of the several groups which make up the system of classification.*[1]

264. *Order of Appearance of Types of Plant Life on the Earth.* — Fossil remains of plants are found preserved in the rocks in so many places that much is known about the early history of plant life. Thallophytes of some kind were undoubtedly the first plants, and more highly organized groups appeared gradually afterward. It is nearly as certain that the more complex and highly specialized forms descended by gradual modifications and improvements from the simpler ones as it is that elm trees a hundred feet in height, with all their complicated structures of root, stem, leaf, and flower, grow from seeds not nearly as large as one's finger-nail. But

[1] See Warming's *Systematic Botany*, Preface and throughout the work. In the little flora which accompanies Part II of the present book, the families are arranged not in the order in which they occur in Gray's *Manual*, but in one which according to the best recent German authorities more nearly represents their relationships.

the study of fossil plants and that of the way in which one group of plants has descended from another are topics too difficult to receive more than a simple mention in an ordinary school botany.

CHAPTER XXIII.

Some Types of Flowerless Plants.[1]

265. *Numerous Classes of Cryptogamous Plants.* — While there are only two classes of flowering plants (§ 256), and only the latter of these need occupy much of the attention of a beginner in botany, there are some fifteen classes of flowerless plants, so that an elementary book on botany can only make the student acquainted with a few specimen groups chosen from among these.

THE STUDY OF PROTOCOCCUS.[2]

266. *Occurrence.* — Protococcus may be found in the water of stagnant pools, particularly of those which contain the drainage of barn-yards or of manure-heaps. It occurs also in the mud at the bottom of eaves-troughs, in barrels containing rain-water, or in water standing in cavities in logs or the stumps of trees. Water containing Protococcus in abundance is greenish (or sometimes reddish) throughout, while examination with the naked eye hardly shows the separate particles to which the color is due. Portions of the mud on which the plant occurs should be carefully scraped off and kept damp for examination, or the water in

[1] The author has introduced the study of a few cryptogamous forms thus late in the present book more out of deference to general usage than because he thinks it to be the best possible order of treatment. He has found it desirable to exhibit (under the microscope) and discuss slides of *Protococcus*, *Pleurococcus*, *Palmella*, and so on, as soon as the pupil is shown the cellular structure of seeds. This emphasizes and makes clear at the outset something of the nature of the vegetable cell. *Protococcus* and *Spirogyra* may be examined for chlorophyll, and their liberation of oxygen in sunlight noted while the work of the leaf is under consideration. Finally the structure and the reproduction of all the cryptogamous forms which are to be considered at all may be investigated and discussed just before the study of the flower is begun.

[2] See Huxley and Martin's *Biology* (extended by Howes and Scott) under Protococcus.

which Protococcus is growing should be put in a shallow dish, loosely covered with a pane of glass, to prevent drying up, and set in a sunny place.[1]

267. *Microscopical Examination of Protococcus.*[2] — Place a drop of water containing Protococcus on a slide, lay on it a cover-glass, and examine with a power of 200 or more diameters. Sketch with the *camera lucida* several divisions of the stage micrometer alongside of one of the largest cells, some of intermediate size, and one of the smallest.[3]

Note the clearly defined cell wall, of cellulose, enclosing the protoplasmic contents, usually green throughout, sometimes red throughout, sometimes of both colors. Do any cells show a nucleus like that in Fig. 102 *e*, *f*, *g*, *k*, *l*?

A *B* *C* *D* *E*

FIG. 190. — A Unicellular Plant (*Palmoglæa*). (Greatly magnified.)

A, a single cell in its ordinary condition, consisting of a mass of protoplasm colored green by chlorophyll and surrounded by a transparent gelatinous envelope; *B*, the cell-contents elongating preparatory to multiplying by fission into two portions; *C*, the process carried a step farther; *D*, the two cells quite distinct, but surrounded by a common gelatinous envelope; *E*, each of the new cells much enlarged and forming a gelatinous envelope of its own.

Test the cells with iodine for starch.

Note that the cell-contents in many individuals has divided into two parts, which become separated from each other by a cellulose partition. The mode of division is not unlike that shown in Fig. 190, but the cells in that figure have not the distinct cell wall that Protococcus has, while they are covered with a layer of gelatinous material not found in Protococcus. After the division of a Protococcus cell into two portions, each may at once constitute a new cell, with a complete sac of cellulose surrounding it, or each of the halves formed by the first sub-division may break up into halves again before the cell wall is formed around the new portions

[1] If it is found impracticable to collect *Protococcus* for examination, the green, powdery *Pleurococcus* found everywhere on the shady sides of trees or unpainted fences will answer very well to show unicellular plants containing chlorophyll, and to illustrate multiplication by cell-division.

[2] Slides permanently mounted and purchasable of the dealers (see Appendix C) will answer for most of the microscopical examinations almost as well as the living cells.

[3] See Clark's *Practical Methods in Microscopy*, pp. 31–35.

268. *Motile Form of Protococcus.* — Occasionally the Protococcus cell may be found in an actively swimming condition, known as its *motile form*. The larger motile cells are either naked or are covered with a transparent cell wall, which the colored cell-contents does not entirely fill. The latter condition is represented by Fig. 191, II. These large motile cells may multiply by a process known as *fission* into twos or fours, or the whole cell-contents may break up into as many as 32 portions, each of which then sets out in an independent existence as a freely swimming spore (*zoöspore*).

The change from the still to the motile form appears to be favored by heat, sunlight, and abundance of air-supply (as by shallowness of the water in which the plants are growing); the reverse change is brought about by conditions just the opposite of those above mentioned.

I II

FIG. 191. — Two Cells of Protococcus. (Greatly magnified.)

I, a spherical cell of the still form; II, a motile cell with its protoplasm enclosed in a loose cell wall and provided with two cilia (§ 161).

269. *Nutrition of Protococcus.* — Protococcus can flourish only in the sunlight, but with a sufficient supply of light it can absorb and fix carbonic acid gas (giving off at the same time bubbles of oxygen) and can assimilate mineral substances. It is a capital example of an individual cell capable of independent existence.

THE STUDY OF SPIROGYRA.[1]

270. *Occurrence.* — *Spirogyra*, one of the plants commonly known as pondscum, or "frog-spit," occurs widely distributed throughout the country in ponds, springs, and clear streams. It is of a green or yellowish-green color, and in sunny weather usually floats on or near the surface of the water buoyed up by the numerous oxygen bubbles which it sets

[1] If *Spirogyra* is not easily found, the teacher may advantageously use *Zygnema* or *Mesocarpus*. He should become familiar with the appearance of some of the fresh-water algæ by microscopical studies of them and by reference to the figures in such works as Wood's *Fresh-Water Algæ*. There are many excellent small cuts of common forms in Campbell's *Elements of Structural and Systematic Botany*, published by Ginn & Co. The teacher may consult this latter book to great advantage throughout his studies on cryptogamous plants.

free. It may be found flourishing in unfrozen springs, even in mid-winter.

271. *Examination with the Magnifying Glass.*[1] — Float a little of the material in a white plate, using just water enough to cover the bottom of the latter. Study with the magnifying glass and note the green color of the threads and their great length as compared with their thickness. Are all the filaments about equal to each other in diameter?

Handle a mass of the material and describe how it feels between the fingers.

FIG. 192. — Cell from a Thread of Pondscum (*Spirogyra*). (Magnified about 90 diameters.)

k, nucleus; *ch*, spiral band containing chlorophyll; *p*, *pyrenoids*, little masses of proteid material with starch-grains.

272. *Examination with the Microscope.*—Mount in water under a large cover-glass and examine first with a power of about 100 diameters, then with a power of 200 diameters or more. Note the structure of the filaments, each made up of a row of cells placed end to end.

Move the slide so as to trace the whole length of several filaments, and, if the unbroken end of one can be found, study and sketch it.

Study with the higher power a single cell of one of the larger filaments and make out the details of structure shown in Fig. 192. Try to ascertain, by focusing, the exact shape of the cell. Count the bands of chlorophyll. The number of bands is an important character in distinguishing one species from another.

Run in five-per-cent salt solution at one edge of the cover-glass (withdrawing water from the other edge with a bit of blotting-paper). If any change in the appearance of the cell becomes evident, make a sketch to show it. What has happened to the cell-contents? Explain, by reference to what you know of osmose, the cause of the change.

On a freshly mounted slide run in iodine solution, a little at a time, and note its action on the nucleus. Is any starch shown to be present? If so, just how is it distributed through the cell?

273. *Reproduction of Spirogyra.* — The reproductive process in *Spirogyra* is of two kinds, the simplest being a process of fission, not unlike that with which the student has become familiar in *Protococcus*. The nucleus undergoes a very complicated series of transformations,

[1] Consult Huxley's *Biology* and Spalding's *Introduction to Botany*.

which result in the division of the protoplasmic contents of a cell into two independent portions, each of which is at length surrounded by a complete cell wall of its own. In Fig. 193 the division of the protoplasm and formation of a partition of cellulose in a kind of pondscum are shown, but the nucleus and its changes are not represented.

Another kind of reproduction, namely by *conjugation*, is found in *Spirogyra*. This process in its simplest form is found in such unicellular plants as the *desmids*, Fig. 194. Two cells (apparently precisely alike) come in contact, undergo a thinning-down or absorptive process in the cell walls at the point of contact, and finally blend their protoplasmic cell-contents, as shown in the figure, to form a mass known as a *spore*, or more accurately a *zygospore*, from which a new individual soon develops. In *Spirogyra* each cell of the filament appears to be an individual and can conjugate like the one-celled *desmids*. It is not easy to watch the process, since the growth of the filaments goes on mainly by day, in sunlight, and the spore-formation takes place at night, when growth is less rapid. It is possible, however, to retard the occurrence of

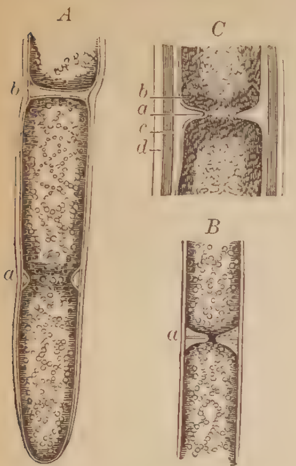


FIG. 193.—Process of Cell-Multiplication in a Species of Pondscum. (Considerably magnified.)

A, portion of a filament partly separated at *a* and completely so at *b*; *B*, separation nearly completed, a new partition of cellulose formed at *a*; *C*, another portion, more magnified, showing mucous covering *d*, general cell wall *c*, and a delicate membrane *a*, which covers the cell-contents *b*.

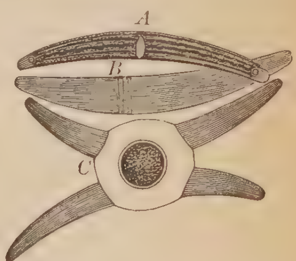


FIG. 194.—Unicellular Fresh-Water Plants (*desmids*), forming Spores by Conjugation. (Much magnified.)

A, a single plant in its ordinary condition; *B*, empty cell wall of another individual; *C*, conjugation of two individuals to form a spore by union of their cell-contents.

conjugation by leaving the Spirogyra filaments in very cold water over night, and in this way the successive steps of the conjugating process may be studied by daylight. In such ways the series of phenomena shown in Fig. 195 has been clearly made out. If the student cannot follow these operations under the microscope, he may at least by looking over the yellower portions of a mass of Spirogyra find threads containing fully formed zygospores, like those shown in *B*, Fig. 195.

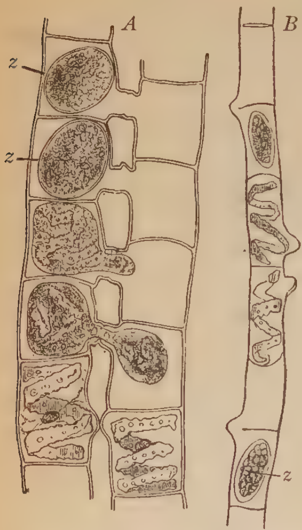


FIG. 195. – Formation of Spores by Conjugation in Spirogyra.

A, two filaments of Spirogyra side by side, with the contents of adjacent cells uniting to form spores *z*. At the bottom of the figure the process is shown as beginning, at the top as completed, and the cells of one filament emptied; *B*, a single filament of another kind of Spirogyra, containing two spores, one lettered *z*. (*A* magnified 240 diameters, *B* 150 diameters.)

ALGÆ.

274. *Characteristics of Algæ.* — The *Protococcus* and the *Spirogyra* are two common fresh-water examples of the kind of plants classed under the general name of *Algæ*, a group of which the largest and most interesting examples are to be found among the seaweeds. Algæ are all aquatic, or at least live usually in damp places; they contain chlorophyll, and are therefore capable of absorbing carbonic acid gas and fixing carbon; few algæ are parasitic or saprophytic. In fact, the main distinction between this group and the *fungi* lies in the self-supporting character of the former plants and the parasitic or saprophytic (§ 151) character of the latter. For this reason the two groups, based on the characteristic behavior or mode of life of their members, rather than on the real relationships of the

latter, are not certain hereafter to be recognized in any strictly scientific classification of cryptogamous plants.

Algæ vary in size from spheres $\frac{1}{10,000}$ inch in diameter to great cable-like masses many hundreds of feet in length. Some species are found in salt, some in brackish, some in fresh water. There are species which occur growing on snow and melting ice, while others form the characteristic vegetation of hot springs, in which they sometimes endure a temperature nearly equal to that of boiling water.

275. *Reproduction in Algæ.* — The reproductive processes in algæ are of several types, which are described in special treatises but cannot be explained in detail in a botany for beginners. Besides the mode by formation of *zoöspores*, as in the *Protococcus*, and that by the formation of *zygospores*, as in the desmids and in *Spirogyra*, there is a very interesting method which may be briefly outlined here, because it represents an important principle in many kinds of reproduction, *the union of fertilizing cells with much larger egg-cells.* This kind of union is well illustrated by one of the very commonest of seaweeds, the common bladder-wrack or rockweed, Fig. 196, which grows on rocks between high and low water mark. It has many flat, leathery branches, which are buoyed up in the water by the air-bladders, *b*. The spores are produced by means of a rather complicated set of organs con-

FIG. 196. — Common Bladder-Wrack or Rockweed, *Fucus vesiculosus*. (Reduced to about ⅓ the natural size.) *b*, air-bladders; *f*, organs for production of spores.

tained in the expanded portions, *f*. In these expansions there are produced somewhat spherical bodies, *A*, Fig. 197, which may be called egg-cells (*oöspheres*), and ciliated fertilizing cells, or *antherozoids*, *G*. After the bursting of the thin membrane, shown at *A*, by which the egg-spheres are confined, they become covered with multitudes of the fertilizing cells, as seen at *F* and *H*, and are often whirled about by the motion of the cilia of these cells. At length, the sub-

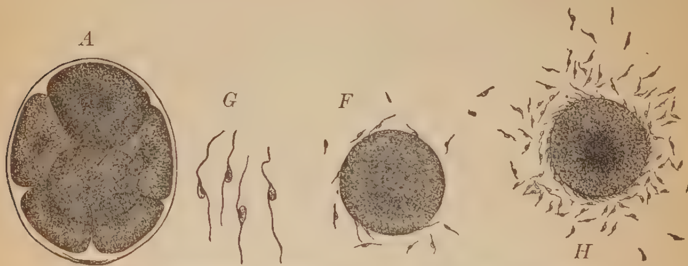


FIG. 197. — Production of Spores of Rockweed. (Much magnified.)[1]
A, a bundle of egg-spheres, or oöspheres (from interior of *f*, Fig. 196); *G*, ciliated fertilizing cells, or antherozoids (from interior of *f*, Fig. 196); *F*, *H*, egg-spheres changing to spores by union of fertilizing cells with their contents. (*G* is magnified more than twice as much as the other parts of the figure.)

stance of one of the ciliated cells becomes mingled with that of the naked protoplasmic egg-sphere, and the latter soon proceeds to develop a cell wall and begins at once to grow into a new plant of rockweed.

THE STUDY OF YEAST.

276. *Growth of Yeast in Dilute Syrup.* — Mix about an eighth of a cake of compressed yeast with about a teaspoonful of water and stir until a smooth thin mixture is formed. Add this to about half a pint of water in which a tablespoonful of molasses has been dissolved. Place this mix-

[1] *A* and *F* of this figure represent the spore-producing apparatus from *Fucus platycarpus*. Fig. 196 is *Fucus vesiculosus*. The principle of spore-formation is very similar in the two species.

ture in a wide-mouthed bottle which holds one or one and a half pints, stopper *very loosely*[1] and set aside for from 12 to 24 hours in a place in which the temperature will be from 70 to 90 degrees. Watch the liquid meantime and note:

(*a*) The rise of bubbles of gas in the liquid.

(*b*) The increasing muddiness of the liquid, a considerable sediment usually collecting at the end of the time mentioned.

(*c*) The effect of cooling off the contents of the bottle by immersing it in broken ice if convenient, or if this is not practicable by standing it for half an hour in a pail of the coldest water obtainable, or leaving it for an hour in a refrigerator, afterwards warming the liquid again.

(*d*) The effect of shutting out light from the contents of the bottle by covering it with a tight box or large tin can.

(*e*) The result of filling a test-tube or a very small bottle with some of the syrup-and-yeast mixture, from which gas-bubbles are freely rising, and immersing the small bottle up to the top of the neck for fifteen minutes in boiling water. Allow this bottle to stand in a warm place for some hours after the exposure to hot water.

(*f*) The behavior of a lighted match lowered into the air-space above the liquid in the large bottle after the latter has been standing undisturbed in a warm place for an hour or more.

(*g*) The smell of the liquid and its taste.

277. *Microscopical Examination of the Sediment.*[2] — Using a very slender glass tube as a pipette, take up a drop or two of the liquid and the upper layer of the sediment and place on a glass slide, cover with a very thin cover-glass and examine with the highest power that the microscope affords.

Note:

(*a*) The general shape of the cells.

(*b*) Their granular contents.

(*c*) The clear spot or vacuole seen in many of the cells.

Sketch some of the groups and compare the sketches with Fig. 198.

Run in a little iodine solution under one edge of the cover-glass, at the same time touching a bit of blotting-paper to the opposite edge, and notice the color of the stained cells. Do they contain starch?

Place some vigorously growing yeast on a slide under a cover-glass and run in a little red ink. Note the proportion of cells which stain at first and the time required for others to stain. Repeat with yeast which has

[1] If the cork is crowded into the neck with any considerable force, pressure of gas and an explosion may result.

[2] See Huxley and Martin, under *Torula.*

been placed in a slender test-tube and held for two or three minutes in a cup of boiling water.

With a very small cover-glass, not more than ⅜ inch in diameter, it may be found possible by laying a few bits of blotting-paper or card-board on the cover-glass and pressing it against the slide to burst some of the stained cells and thus show their thin, colorless *cell walls* and their semi-fluid contents, *protoplasm*, nearly colorless in its natural condition but now stained by the iodine.

278. ***Experiment 33.*** *Can Yeast grow in Pure Water or in Pure Syrup?* — Put a bit of compressed yeast of about the size of a grain of wheat in about four fluid-ounces of distilled water, and another bit of about the same size in four fluid-ounces of 10-per-cent solution of rock candy in distilled water; place both preparations in a warm place, allow to remain for 24 hours and examine for evidence of the growth of the yeast added to each.

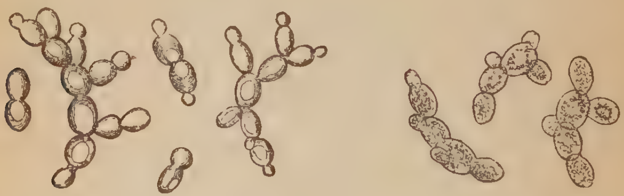


FIG. 198. — Two Species of Yeast, increasing by Budding. (Greatly magnified.) I, a species with the buds very numerous and well defined. II, the common species.

279. *Size, Form, and Structure of the Yeast Cell.* — The student has discovered by his own observations with the microscope that the yeast cell is a very minute object, — much smaller than most of the vegetable cells which he has hitherto examined. The average diameter of a yeast cell is about $\frac{1}{3000}$ of an inch, but they vary greatly both ways from the average size. (Measure an average cell in Fig. 198, II, and calculate about how many diameters magnifying power were used for that figure.)

The general form of most of the cells of ordinary yeast is somewhat egg-shaped. The structure is extremely simple, consisting of a thin cell wall, which is wholly destitute of markings, and a more or less granular semi-fluid protoplasm, sometimes containing a portion of clearer liquid, the *vacuole*, well shown in the larger cells of Fig. 198, I.

280. *Substances which compose the Yeast Cell.* — The cell wall is composed mostly of *cellulose*, the protoplasm consists largely of water together with considerable portions of a proteid substance,[1] some fat, and very minute portions of *sulphur*, *phosphorus*, *potash*, *magnesia*, and *lime*. It is destitute of chlorophyll, as would be inferred from its lack of green color, and contains no starch.

281. *Food of the Yeast Cell, Fermentation.* — Yeast cannot grow much in pure water nor in pure solution of sugar. The diluted molasses in which it was grown in Exp. 33 contained all the mineral substances mentioned in § 280, together with sugar, proteid materials, and water. The addition of a little nitrate of ammonium would probably have aided the growth of the yeast in this experiment, by supplying more abundantly the elements out of which the yeast constructs its proteid cell-contents. A great deal of sugar disappears during the growth of the yeast.[2] Most of the sugar destroyed is changed into carbonic acid gas (which the student saw rising through the liquid in bubbles), and alcohol, which can be separated from the liquid by simple means. The process of breaking up weak syrup into carbonic acid and alcohol by aid of yeast is called *fermentation*, it is of great practical importance in bread-making and in the manufacture of alcohol. Since grape juice, sweet cider, molasses-and-water, and similar liquids when merely exposed to the air soon begin to ferment, and are then found to contain growing yeast, it is concluded that dried yeast cells, in the form of dust, must be everywhere present in ordinary air.

282. *Yeast a Plant; a Saprophyte.* — The yeast cell is known to be a plant, and not an animal, from the fact of its producing a coating of cellulose around its protoplasmic contents and from the fact that it can produce proteids out of substances from which animals could not produce them.[3]

On the other hand, yeast cannot live wholly on carbonic acid gas, nitrates,

[1] It may be found troublesome to apply tests to the yeast cell on the slide, under the cover-glass. Testing a yeast cake is not of much value, unless it may be assumed that compressed yeast contains little foreign matter and consists mostly of yeast cells. Still the test is worth making. Millon's reagent does not work well, but the red or maroon color which constitutes a good test for proteids is readily obtained by mixing a teaspoonful of granulated sugar with enough strong sulphuric acid to barely moisten the sugar throughout, and then, as quickly as possible, mixing a bit of yeast cake with the acid and sugar. A comparative experiment may be made at the same time with some other familiar proteid substance, *e.g.*, wheat germ meal.

[2] The sugar contained in molasses is partly cane sugar and partly grape sugar. Only the latter is detected by the addition of Fehling's solution. Both kinds are destroyed during the process of fermentation.

[3] For example, tartrate of ammonia.

water, and other mineral substances, as ordinary green plants can. It gives off no oxygen, but only carbonic acid gas, and is therefore to be classed with the *saprophytes*, like the Indian pipe among flowering plants, § 151.

283. *Multiplication of Yeast.* — While yeast cells are under favorable conditions for growth, they multiply with very great rapidity. Little protrusions are formed at some portion of the cell wall, as the thumb of a mitten might be formed by a gradual outgrowth from the main portion. Soon a partition of cellulose is constructed, which shuts off the newly formed outgrowth, making it into a separate cell, and this in turn may give rise to others, while meantime the original cell may have thrown out other offshoots. The whole process is called *reproduction by budding.* It is often possible to trace at a glance the history of a group of cells, like those of the right-hand cluster in Fig. 198, II, the oldest and largest cell being somewhere near the middle of the group and the youngest and smallest members being situated around the outside. Less frequently the mode of reproduction is by means of *spores*, new cells (usually four in number), formed inside one of the older cells. At length the old cell wall bursts and the spores are set free, to begin an independent existence of their own.

In examining the yeast cell, the student has been making the acquaintance of plant life reduced almost to its lowest terms. The very simplest plants consist, like the slime-moulds, of a speck of jelly-like protoplasm. Yeast is more complex, from the fact that its protoplasm is surrounded by an envelope of cellulose, the cell wall.

THE STUDY OF BLACK MOULD.[1]

284. *Occurrence.* — This mould may be found in abundance on decaying fruits, such as tomatoes, apples, peaches, grapes, and cherries, or on decaying sweet potatoes or squashes. For class study it may most conveniently be obtained by putting pieces of wet bread on plates for a few days under bell jars and leaving in a warm place until patches of the mould begin to appear.[2]

[1] *Rhizopus nigricans.* If any difficulty is experienced in procuring material for study, the common sage-green mould, *Penicillium glaucum*, can always be procured and propagated as described in Huxley and Martin's *Biology.*

[2] It will always be found much easier to obtain a good crop of the desired mould by sowing its spores upon the wet bread that is used. Spores may be kept indefinitely, in a dry condition, for this purpose. Exposing the bread to a confined portion of the atmosphere of any place, *e.g.*, a cellar, where the desired mould has previously flourished will insure a prompt growth of the mould anew.

285. *Examination with the Magnifying Glass.* — Study some of the larger and more mature patches and some of the smaller ones. Note :

(*a*) The slender, thread-like network with which the surface of the bread is covered. The threads are known as *hyphæ*, the entire network is called the *mycelium*.

(*b*) The delicate threads which rise at intervals from the mycelium and are terminated by small globular objects. These little spheres are spore-cases. Compare some of the spore-cases with each other and notice what change of color marks their coming to maturity.

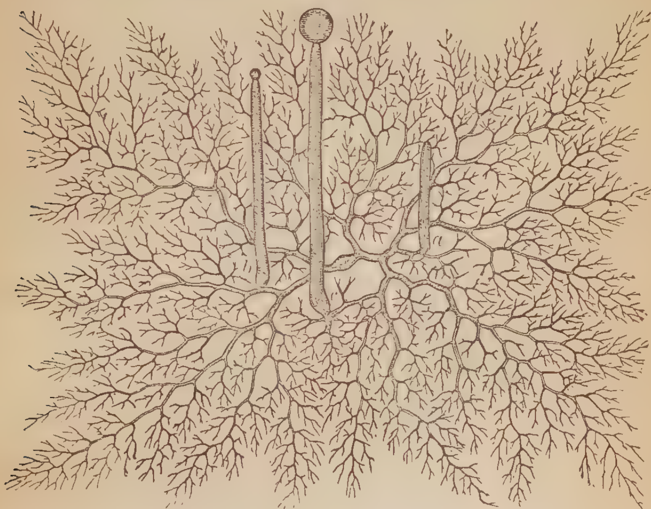


FIG. 199. — Unicellular Mycelium of a Mould (*Mucor Mucedo*), sprung from a Single Spore.

a, *b*, and *c*, branches for the production of spore-cases showing various stages of maturity. (Considerably magnified.)

286. *Examination with the Microscope.* — Sketch a portion of the untouched surface of the mould as seen (opaque) with a two-inch objective, then compare with Fig. 199.

Wet a bit of the mould, first with alcohol, then with water. Examine in water with the half-inch objective and sketch a little of the mycelium, some of the spore-cases, and the thread-like stalks on which they are

borne. Are these stalks and the mycelium filaments solid or tubular? Are they one-celled or several-celled?

Mount some of the mature spore-cases in water, examine them with the highest obtainable power, and sketch the escaping spores.

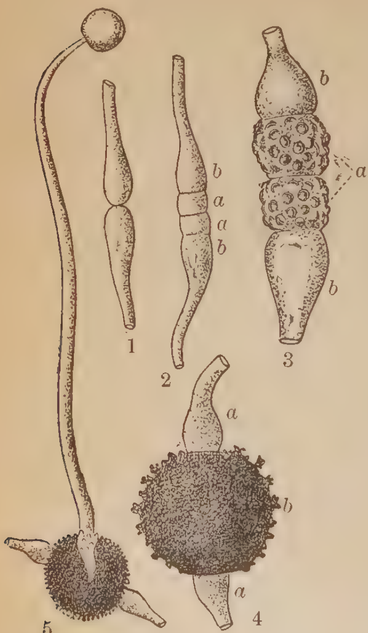


FIG. 200. — Formation of Zygospores in a Mould (*Mucor Mucedo*).

1, threads in contact previous to conjugation; 2, cutting off of the conjugating cells, *a*, from the threads, *b*; 3, a later stage of the process; 4, ripe zygospore; 5, germination of a zygospore and formation of a spore-case. (1-4 magnified 225 diameters, 5 magnified about 60 diameters.)

Sow some of these spores[1] on the surface of "hay-tea," made by boiling a handful of hay in just water enough to cover it and then straining through cloth or filtering through a paper filter. After from three to six hours, examine a drop from the surface of the liquid with a medium power of the microscope (half-inch objective) to see how the development of hyphæ from the spores begins. Sketch.

After about 24 hours examine another portion of the mould from the surface of the liquid and study the more fully developed mycelium. Sketch.

287. *Zygospores.* — Besides the spores just studied, *zygospores* are formed by conjugation of the hyphæ of the black moulds. It is not very easy to find these in process of formation, but the student may be able to gather from Fig. 200 the nature of the process by which they are formed: a process which cannot fail to remind him of the conjugation of pondscum.

FUNGI.

288. *Characteristics of Fungi.* — The yeasts and the moulds are humble representatives of an immense multitude of para-

[1] The spores of *Penicillium* will do as well.

sitic or saprophytic plants which were formerly all grouped as *fungi*, but which now are often divided among many classes.[1] Chlorophyll is absent from fungi, and they are destitute of starch, but produce a kind of cellulose which appears to differ chemically from that of other plants. Unable to build up their tissues from carbonic acid gas, water, and other mineral matters, they are to be classed, with animals, as consumers rather than as producers, acting on the whole to diminish rather than to increase the total amount of organic material on the earth.

289. *Occurrence and Mode of Life of Fungi.* — Among the most important cryptogamous plants are those which, like the bacillus of consumption, of diphtheria, of typhoid fever, or of cholera, produce disease in man or in the lower animals. The sub-class which includes these plants is known by the name *Bacteria*. Some of the most notable characteristics of this group are their extreme minuteness and their extraordinary power of multiplication. Many bacteria are on the whole highly useful to man, as is the case with those which produce decay in the tissues of dead plants or animals, since these substances would, if it were not for the destructive action of the bacteria of putrefaction and fermentation, remain indefinitely after death to cumber the earth and lock up proteid and other food needed by new organisms.

The "rust" of wheat and the "smut" of corn are well-known fungi parasitic on other plants, and the number of such species of fungi already known is not less than 42,000. Fig. 201 shows clearly how a parasitic fungus grows from a spore which has found lodgment in the tissues of a leaf and pushes out stalks through the stomata.

The largest fungi are those of the group to which the edible mushrooms, the toadstools, puffballs, and so on, belong.

[1] See Strasburger, Noll, Schenck, and Schimper's *Lehrbuch*, pp. 262, 263; also Warming's *Systematic Botany* (translated by Potter), p. 1.

The mycelium of these is generally concealed in the substance of the earth, decaying wood, or other material on which the fungus grows, and the conspicuous portion of the plant is that on which the spores are borne.

Lichens, familiar objects encrusting rocks or hanging in

FIG. 201. — Spore-Formation in Potato Blight (*Phytophthora infestans*). *A*, an unbranched stalk, proceeding from the mycelium *m* in the interior of the potato leaf, passing out of the epidermis *e* through the stoma *sp*, and bearing a single spore-case ; *B*, an older group of stalks, showing spore-cases in various stages. (Both greatly magnified, *A* more highly than *B*.)

beard-like tufts from the bark of trees, which were once regarded as constituting a separate division of the vegetable kingdom, are now known to be curious examples of a kind of

partnership which occurs both among plants and among animals. The so-called lichen is really a complex colony composed of a multitude of minute fungi living in close connection with certain thread-like algæ. The partnership between the two kinds of plants is not an especially one-sided affair; though the algæ are the principal breadwinners of the firm, their association with the fungi enables them to live in situations and under conditions that would be fatal to the algæ alone.

290. *Reproduction in Fungi.* — The reproductive processes in fungi are so various in their character, and involve so much microscopical study, if they are to be clearly understood, that it would require many chapters to describe them. The examples already considered in the cases of yeast and the moulds must be allowed to stand as representatives of the great number of interesting types that offer themselves to the student of this department of cryptogamic botany.

THE STUDY OF PIGEON-WHEAT MOSS.[1]

291. *Occurrence.* — This moss, Fig. 202, is widely distributed over the surface of the earth, and some of its species are among the best-known mosses of the northern United States. Here it grows commonly in dry pastures or on hillsides, not usually in densely shaded situations.

292. *Form, Size, and General Characters.* — Study several specimens which have been pulled up by the roots.[2] Note the size, general form, color, and texture of all the parts of the plants examined. Some of them probably bear *urns* or *spore-capsules* like those shown in Fig. 202, while others are without them. Sketch one plant of each kind, about natural size.

What difference is noticeable between the appearance of the leaves in those plants which have spore-cases and those which have none? Why is this?

[1] *Polytrichum commune.* This is selected as one of the largest and commonest of mosses. If any other genus is more readily obtainable, the teacher may as well use it. For an excellent account of the structure and physiology of mosses, consult Bennett and Murray's *Cryptogamic Botany.* For the determination of species, see Lesquereux and James' *Mosses of North America.*

[2] Fresh specimens are best, but dried ones will do nearly as well.

FIG. 202. — A Plant of Pigeon-Wheat Moss (*Polytrichum commune*). *rh*, root-like portion; *s*, bristle-like stalk of urn, or spore-case; *c*, hoodlike cover of urn; *ap*, knob at base of urn; *d*, cover of urn. (Natural size.)

In some specimens the stem may be found, at a height of an inch or more above the roots, to bear a conical, basket-shaped enlargement, out of the centre of which a younger portion of the stem seems to proceed, and this younger portion may in turn end in a similar enlargement, from which a still younger part proceeds.

Note the difference in general appearance between the leaves of those plants which have just been removed from the moist collecting-box and those which have been lying for half an hour on the table. Study the leaves in both cases with the magnifying glass in order to find out what has happened to them. Of what use to the plant is this change? Put some of the partially dried leaves in water, in a cell on a microscope slide, cover, place under the lowest power of the microscope, and examine at intervals of ten or fifteen minutes. Finally sketch a single leaf.

293. *Minute Structure of the Leaf and Stem.* —The cellular structure of the pigeon-wheat moss is not nearly as simple and convenient for microscopical study as is that of the smaller mosses, many of which have leaves composed, over a large part of their surfaces, of but a single layer of cells, as shown in Fig. 205. If any detailed study of the structure of a moss is to be made it will, therefore, be better for the student to provide himself with specimens of almost any of the smaller genera,[1] and work out what he can in regard to their minute anatomy.

294. *Spore-Capsules.* — That part of the reproductive apparatus of a common moss which is most apparent at a glance is the *urn* or *spore-capsule*, Fig. 202. This is covered until it reaches maturity with a hood which is easily detached. Remove the hood from one of the

[1] As *Mnium* or *Bryum*.

urns, examine with the magnifying glass, and sketch it. Note the character of the material of which its outer layer is composed.

FIG. 203.

A, longitudinal section of summit of a small archegonium-bearing plant of *Funaria hyrometrica*, a moss; *a*, archegonia; *b*, leaves. *B*, an archegonium of the same moss; *m*, mouth; *h*, neck; *b*, enlarged portion, containing the oösphere. (*A* magnified 100 diameters; *B* magnified 550 diameters.)

FIG. 204.

A, a bursting antheridium of *Funaria hygrometrica*, a moss; *a*, the antherozoids; *B*, the antherozoids more strongly magnified, in the mother cell; *c*, antherozoid of pigeon-wheat moss (*Polytrichum*). (All much magnified.)

Sketch the uncovered urn, as seen through the magnifying glass, noting the little knob at its base and the circular lid.

Pry off this lid, remove some of the mass of spores from the interior of the urn, observe their color as seen in bulk through the magnifying glass, then mount in water, examine with the highest obtainable power of the microscope and sketch them. These spores, if sown on moist earth, will each develop into a slender, branched organism, consisting, like pondscum, of single rows of cells, Fig. 206, called the *protonema.*

FIG. 205. — Longitudinal Section of the Summit of a very Small Antheridium-Bearing Plant of *Funaria hygrometrica*, a Moss.

a, young antheridium ; *b*, nearly mature antheridium ; *c*, appendages growing among the antheridia ; *d*, leaves cut through the midrib ; *e*, leaves cut through the blade. (Magnified 300 diameters.)

295. *Other Reproductive Apparatus.* — The student cannot, without spending a good deal of time and making himself expert in the examination of mosses, trace out for himself the whole story of the reproduction of any moss. It is sufficient here to give an outline of the process. The protonema develops buds, one of which is shown in Fig. 206, and the bud grows into an ordinary moss plant. This plant, in the case of the pigeon-wheat moss, bears organs of a somewhat flower-like nature, Fig. 205, which contain either *antheridia*, Fig. 204, organs which produce fertilizing cells called *antherozoids*, or *archegonia*, Fig. 203, organs which produce *oöspheres* (§ 275), but in this moss antheridia and archegonia are not produced in the same "moss-flower." The plants therefore correspond to diœcious ones among flowering plants.

After the fertilization of the oösphere, by the penetration of antherozoids to the bottom of the flask-shaped archegonium, the development of the oösphere into an urn begins, the latter rises on its slender stalk, while the upper part of the archegonium is carried with it and persists for a time as the hood, Fig. 202, *c*.

MOSSES.

296. *Mosses have Specialized Organs.* — In his examination of a moss the student at once recognizes it as a distinct advance from the kind of plant life exemplified by any of the cryptogamous types which he has previously studied. Root, stem, and leaf, as found in flowering plants, are represented by organs of similar function, though not of similar structure to true roots, stems, and leaves. The principle of *physiological division of labor*, so characteristic of the higher plants, is fairly exemplified in mosses. Although destitute of true flowers, they possess flower-like organs which may be either monœcious or diœcious.

297. *Alternation of Generations.* — In mosses, as in the simpler liverworts, below them, and the more complex ferns, above them, the reproductive process includes what is known as an *alternation of generations.* That is to say, the organs of reproduction produce a spore which does not grow directly into a new individual like the parent. The fertilized oösphere

produces the urn or spore-capsule, and this is really a new plant. It remains attached to the parent plant and is nourished by it, does not grow to any considerable size, but develops a great number of spores in its interior. These spores when fully formed are set free, germinate, and produce a thread-like protonema, which at length grows into the fully developed moss plant. The two generations, then, are the moss, with its rather complicated reproductive apparatus, and the urn,

FIG. 206.

B, protonema of *Funaria hygrometrica*, a moss; *h*, a well-developed primary shoot; *K*, rudiment of a leaf-bearing axis, or ordinary moss plant, like Fig. 202; *w*, a root-hair. (Magnified about 90 diameters.)

destitute of such apparatus but filled with spores which are merely the product of continued cell-division in the interior of the spore-capsule.

298. *Nutrition in Mosses.* — Mosses, like the higher plants, draw their food supply partly in a liquid form from the earth and partly in a gaseous form from the air. It is interesting to notice, in passing, that one of the best plants with which

to illustrate the process of setting free oxygen, which accompanies fixation of carbon (§ 149), is an aquatic moss.[1]

THE STUDY OF A FERN.[2]

299. *Conditions of Growth.* — If the specimens studied were collected by the class, the collectors should report exactly in regard to the soil and exposure in which the plants were found growing. Do any ferns occur in surroundings decidedly different from these? What kind of treatment do ferns need in house culture?

300. *The Underground Portion.* — Dig up the entire underground portion of a plant of lady-fern. Note the color, size, shape, and appendages of the rootstock. If any are at hand which were collected in their late winter or early spring condition, examine into the way in which the leafy parts of the coming season originate from the rootstock, and note their peculiar shape. This kind of vernation is decidedly characteristic of ferns. Observe the number and distribution of the roots along the rootstock. Bring out all these points in a sketch.

301. *The Frond.* — Fern leaves are technically known as *fronds.* Observe how these arise directly from the rootstock.

Make a somewhat reduced drawing of the entire frond, which consists of a slender axis, or *rhachis*, along which are distributed many leaflets or *pinnæ*, each composed of many *pinnules.* Draw the under side of one of the pinnæ, from near the middle of the frond, enlarged to two or three times its natural size, as seen through the magnifying glass. Note just how each pinnule is attached to its secondary rhachis.

Examine the under side of one of the pinnules (viewed as an opaque object without cover-glass) with the lowest power of the microscope, and note:

(*a*) The "fruit-dots" or *sori* (already seen with the magnifying glass, but now much more clearly shown).

(*b*) The membranous covering or *indusium* of each sorus. Observe how this is attached to the veins of the pinnule. In such ferns as the common brake (*Pteris*) and the maiden-hair (*Adiantum*) there is no separate indusium, but the spore-cases are covered by the incurved edges of the fronds.

[1] Fontinalis.

[2] The outline here given applies exactly only to *Asplenium filix-fœmina.* Any species of *Asplenium* or of *Aspidium* is just as well adapted for study. *Cystopteris* is excellent, but the indusium is hard to find. *Polypodium vulgare* is a simple and

(c) The coiled spore-cases or *sporangia*, lying partly covered by the indusium. How do these sporangia discharge their spores?

Make a drawing, or several drawings, to bring out all these points.

Examine some of the sporangia, dry, with a power of about 50 or 75 diameters, and sketch. Scrape off a few sporangia, thus disengaging some spores, mount the latter in water, examine with a power of about 200 diameters, and draw.

302. *Life History of the Fern.* — When a fern-spore is sown on damp earth it gradually develops into a minute, flattish object, called a *prothallium*, Fig. 208. It is a rather tedious process to grow prothallia from spores, and the easiest way to get them for study is to look for them on the earth or on the damp outer surface of the flower-pots in which ferns are growing in a greenhouse. All stages of germination may readily be found in such localities.

Any prothallia thus obtained for study may be freed from particles of earth by being washed, while held in very small forceps, in a gentle stream of water from a wash-bottle. The student should then mount the prothallium, bottom up, in water in a shallow cell, cover with a large cover-glass, and examine with the lowest power of the microscope. Note:

(*a*) The abundant root-hairs, springing from the lower surface of the prothallium.

(*b*) The variable thickness of the prothallium, near the edge consisting of only one layer of cells.

(*c*) (In some mature specimens) the young fern growing from the prothallium, as shown in Fig. 208, *B*.

The student can hardly make out for himself, without much expenditure of time, the structure of the *antheridia* and the *archegonia*, by the coöperation of which fertilization takes place on much the same plan as that already described in the case of mosses. The fertilized *oösphere* of the archegonium gives rise to the young fern, which grows at first at the expense of the parent prothallium but soon develops roots of its own and leads an independent existence.

The mature fern makes its living, as flowering plants do, by absorption of nutritive matter from the soil and from the air, and its abundant chlorophyll makes it easy for the plant to decompose the supplies of carbonic acid gas which it takes in through its stomata.

generally accessible form, but has no indusium. *Pteris aquilina* is of world-wide distribution, but differs in habit from most of our ferns. The teacher who wishes to go into detail in regard to the gross anatomy or the histology of ferns as exemplified in *Pteris* will find a careful study of it in Huxley and Martin's *Biology*, or a fully illustrated account in Sedgwick and Wilson's *Biology*.

FIG. 207. — A Fern (*Aspidium Filix-mas*).

1, general view of the plant; *a*, young fronds unrolling; 2, cross-section of the rootstock, showing fibro-vascular bundles, *a a*; 3, a pinnule with fruit-dots; *a a*, indusium; *b*, spore-cases; 4, vertical section through 3 *a*; 5, vertical section at right angles to that of (4), showing: *a*, section of pinnule of leaf; *b*, section of indusium; *c*, spore-cases; 6, a single spore-case, with its stalk, *a*, and its elastic ring, *c*, discharging spores at *d*. (1 is reduced to about $\frac{1}{5}$ natural size; 2, 3, are slightly magnified; 4 is more magnified; 5, 6 are considerably magnified.)

FERNS.

303. *Structure, Form, and Habits of Ferns.* — The structure of ferns is much more complex than that of any of the groups of cryptogamous plants discussed in the earlier portions of the present chapter. They are possessed of well defined fibro-vascular bundles, they form a variety of parenchymatous cells, the leaves have a distinct epidermis and are provided with stomata.

Great differences in size, form, and habit of growth are found among the various genera of ferns. The tree ferns of

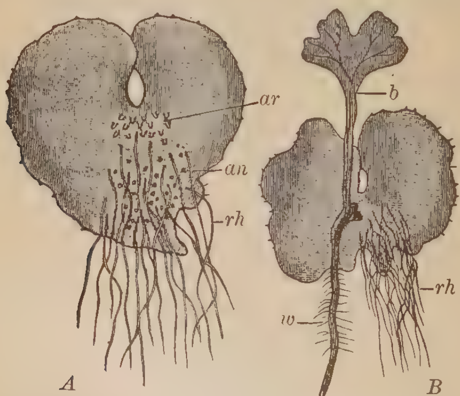


FIG. 208. — Prothallia of a Fern (*Aspidium Filix-mas*).

A, lower side of prothallium; *ar*, archegonia; *an*, antheridia; *rh*, root-hairs; *B*, prothallium producing a young fern plant; *b*, the first leaf; *w*, the root. (Magnified about 8 diameters.)

South America and of many of the islands of the Pacific ocean sometimes rise to a height of forty feet, while the most minute species of temperate and colder climates are not as large as the largest mosses. Some species climb freely, but most kinds are non-climbing plants of moderate size, with well developed rootstocks, which are often, as in the case of

the bracken-fern, or brake,[1] and in *Osmunda*, very large in proportion to the parts of the plant visible above ground.

304. *Economic Value of Ferns.* — Ferns of living species have little economical value, but are of great interest, even to non-botanical people, from the beauty of their foliage.

During that vast portion of early time known to geologists as the Carboniferous Age the earth's surface in many parts must have been clothed with a growth of ferns more dense than is now anywhere found. These ferns, with other flowerless herbs and tree-like plants, produced the vegetable matter out of which all the principal coal-beds of the earth have been formed.

305. *Reproduction in Ferns.* — The reproduction of ferns is a more interesting illustration of alternation of generations than is afforded by mosses. The fruiting plant is the minute prothallium, and the non-fruiting plant, which we commonly call the fern, is merely an outgrowth from the fertilized oösphere, and physiologically no more important than the urn of a moss, except that it supplies its own food instead of living parasitically. Like this urn, the fern is an organism for the production of unfertilized spores, from which new plants endowed with reproductive apparatus may grow.

306. *Relation of Reproduction in Ferns to that in Flowering Plants.* — Botanists have been able to trace out in great detail the true relation which such forms of reproduction as occur in mosses and in ferns bear to that of flowering plants. Stated in the merest outline their conclusions are that the nucleated ovule cell or egg-cell (*e*, Fig. 142) which is fertilized by the pollen tube corresponds to the oösphere, and that part of the contents of the pollen-grain corresponds to the antherozoid.[2]

[1] *Pteris aquilina.*

[2] See Strasburger, Noll, Schenk, and Schimper, *Lehrbuch*, pp. 372–376, and Potter's Warming's *Systematic Botany*, pp. 234–250.

APPENDIX A.

THE USE OF THE COMPOUND MICROSCOPE.

The Instrument. — For elementary class work, a low-priced but strong and well-made instrument is needed. Several of the European makers furnish excellent instruments for use in such a course as that here outlined. Among these are the Leitz microscopes, which are furnished by Wm. Krafft, 411 West 59th St., New York City, and those of Nachet, sold by the Franklin Educational Co., 15 and 17 Harcourt St., Boston. The Leitz stand, No. IV, can be furnished duty free (for schools only), with objectives 1, 3, and 5, eye-pieces I and III, for $24.50. If several instruments are being provided, it would be well to have part of them equipped with objectives 3 and 7, and eye-pieces I and III. The best form of camera lucida for this microscope costs (duty free) $7.80.

The American manufacturers, Bausch & Lomb Optical Company, Rochester, N. Y., and No. 130 Fulton Street, New York City, have recently produced a microscope of the Continental type which is especially designed to meet the requirements of the secondary schools for an instrument with rack and pinion coarse adjustment and serviceable fine adjustment, at a low price. They furnish this new stand, "AAB," to schools and teachers at "duty-free" rates, the prices being, for the stand with two eye-pieces (any desired power), $\frac{2}{3}$-inch and $\frac{1}{4}$-inch objectives, $25.60, or with 2-inch, $\frac{2}{3}$-inch and $\frac{1}{4}$-inch objectives, and two eye-pieces, $29.20.

Stand "A," the same stand as the "AAB," without joint and with sliding tube coarse adjustment (as in the Leitz Stand IV), and with three eye-pieces and $\frac{2}{3}$-inch and $\frac{1}{4}$-inch objectives, is furnished for $20.40. Stand "A," with two eye-pieces, $\frac{2}{3}$-inch and $\frac{1}{6}$-inch objectives, $20.40.

Class Use of the Microscope. — If the class works in a special laboratory in small divisions (not more than twelve), the teacher can examine the preparation of the object, the focusing of the instrument,

and the sketch which the pupil is making, — all while the work is going on. But if the class unfortunately consists of from twenty-five to forty pupils, in an ordinary recitation room, a good deal of ingenuity will be needed to secure results of any value.

The microscopes with the prepared objects should be placed upon the desks or tables which are best lighted.

If there are several instruments it will usually be found preferable to use all of them during any given recitation upon preparations of the same object, but to have some provided with lower and others with higher powers.

It is important to have a card attached to each microscope stating what object is upon the stage and what magnifying power is given by the combination in use. The class may sometimes be divided and half, or less than half, be allowed to work with the microscope while the rest are engaged in written or oral recitation, or in examining the gross anatomy of the seed, root, stem, etc. Each student should be required to take his note-book to the microscope and draw while at the instrument.

Several of the best sketches may be put on the board toward the end of the hour, and a composite drawing finally made, embodying the best portions of each. A still better plan is to have posted at the last a drawing which the instructor has prepared beforehand (best with the aid of the *camera lucida*, or from a photo-micrograph), and if desirable to have this copied by the class. The object sought should be to make the pupils see as much as possible for themselves, but to make sure before leaving the object that they see it as it really is.

Magnifying Power. — The lowest magnifying power which will show the desired structure is to be preferred, both because this admits of the best illumination and because an average focusing which will suit most of the eyes in the class can be secured with objectives of $\frac{1}{2}$-inch or longer focus, but not with higher powers. Constant use should be made of the $1\frac{1}{2}$-inch or 2-inch objective to give general views of the object. A double nose-piece with 2-inch and $\frac{1}{2}$-inch, or 1-inch and $\frac{1}{4}$-inch objectives attached will save much time and trouble.

The class may best be made to understand the meaning of the

term magnifying power by examining the same simple object as seen with several powers. For instance, a letter of ordinary print (*e.g.*, the finest used in this book), may be examined with the naked eye and with the magnifying glass. Then sketches on cardboard may be handed round to show the size of the object, drawn with the camera lucida as seen under the 2-inch objective, with others drawn to scale, to show the effect of all the other magnifying combinations which the microscopes belonging to the school afford.

For further suggestions in regard to the manipulation and use of the microscope the teacher is referred to any of the standard works on the subject. The little book of Charles H. Clark, cited in the bibliography (Appendix D), is compact and usable.

An important adjunct to the microscopical work (or, if need be, a partial substitute for it) consists in the use of photomicrographs of the most important tissues. The mounted silver-prints, or unmounted blue-prints, may be numbered and given out to the division for study at the desk *after the structure in question has been studied with the microscope.* Ample time should be given for careful examination of the pictures thus given out, and then the members of the division may be questioned individually on the photographs, or a written exercise may be set, in which all shall write as fully as possible about a designated number of the photomicrographs examined. The teacher will find that the prints differ just enough from the somewhat diagrammatic or idealized cuts usually given in books to afford an admirable opportunity for the pupil to exercise his powers of observation and discrimination in making out the exact nature of the several tissue elements to be found in each photograph.

APPENDIX B.

APPARATUS AND REAGENTS.

Requisites for each Student. — Every member of the class should have :

Two or three mounted needles. (Prepared by forcing fine needles, eye foremost, into round slender sticks, *e.g.*, old penholders.)

A sharp penknife or a scalpel.

A pair of small steel forceps.

A good magnifying glass ; Coddington lenses are excellent, but rather expensive. The ordinary tripod magnifier which costs at wholesale 30 or 40 cents will answer fairly well.[1]

A large note-book of unruled paper for drawing.

A drawing pencil.

A ruled note-book for record of experiments, etc.

General Equipment of Apparatus. — Compound microscopes, as described in Appendix A.

It is desirable to have one for the use of each member of the division. Usually it is not possible to secure nearly as many instruments as this. Much good work may be done with only one or two microscopes, but in this case the microscopical work will have to be done partly out of the regular class hour and part of it must be carried along while the class as a whole is doing other than microscopical work.

A set of photomicrographs of some of the most important tissues described in the text, or of similar ones.

Mr. W. H. Walmsley, 4248 Pine Street, Philadelphia, Pa., who bears a national reputation for the excellence of his photomicrographs, and has lately given much attention to botanical work, has undertaken to prepare a set of 24 negatives to illustrate the set of microscopic prepa-

[1] An achromatic doublet, made by Leitz, superior to the Coddington lens, can be imported duty free for $2. It magnifies 8 times.

rations described on pages 256, 257. The subjects chosen are slides 1, 2, 3, 4, 5, 7, 8, 9, 11, 13, 14, 16, 17, 20, 21, 22. A price-list of these photomicrographs, together with many hundreds of others on botanical subjects, will soon be issued by Mr. Walmsley, who will meantime furnish the set above mentioned to teachers who wish them. Among the other botanical photomicrographs which Mr. Walmsley has in stock are those of starches, pollen, sections of woods and stems, ovaries (sections), spiral and annular vessels, leaf-sections, stomata, leaf-scales and hairs, mosses (entire), algæ (marine and fresh-water), fungi.

Miss E. M. Drury, 45 Munroe Street, Roxbury (Boston), Mass., will furnish photomicrographs of the same set of 24 (from Mr. Walmsley's negatives). Her prices will be: for unmounted blue-prints, $0.85 per dozen; for mounted silver-prints, $2.00 per dozen.

A small balance.

The hand-scale with 5-inch beam and set of weights from .01 gram to 20 grams, furnished by Eimer & Amend of 205–211 Third Avenue, New York, for about $2, is good enough.

A trip-scale.

The "Harvard trip-scale," furnished by the Fairbanks Scale Co., for about $5.70, is well adapted for weighing potted plants for transpiration experiments, etc.

A cylindrical graduate of 250 to 500 cubic centimeters capacity.

One or two large bell glasses.

Inexpensive one and two quart battery jars for use in cultivating potted plants, — for transpiration experiments. (Earthen flower-pots are not so good, because they permit too much evaporation through their sides.)

Six or eight-quart dishes for germination experiments.

Wide-mouthed bottles.

Glass cylinders of about 300 cubic centimeters capacity for water cultures.

A section-knife, or a razor, flat-ground on one side, hollow-ground on the other.

An Arkansas oilstone.

Watch-glasses.

Glass-stoppered reagent bottles.

Assorted corks and rubber stoppers.

Microscope slides.

Thin glass covers.

Thin sheet rubber, such as is used by dentists, in pieces about 24 inches square (this is not needed if the teacher prefers to use sheet lead in the transpiration experiment; see page 115).

General Reagents and other Supplies. — Alcohol, commercial, 95%.

Alcohol, absolute, a few ounces only.

Hæmatoxylin solution.[1]

Canada balsam.

Caustic potash solution, one part of solid caustic potash in 20 parts distilled water.

Nitric acid, concentrated.

Red ink.[2]

Potassium chlorate.

Fehling's solution, test for grape sugar. This reagent may best be bought of the wholesale druggist or dealer in chemicals. It may be prepared by dissolving 34.64 grams pure crystallized cupric sulphate in 200 cubic centimeters water and mixing the solution with 150 grams neutral potassic tartrate, dissolved in about 500 cubic centimeters of a 10-per-cent solution of sodium hydrate. The whole is then to be diluted with water to 1 litre and 100 cubic centimeters glycerine added.

Millon's reagent for proteids. Prepared by dissolving 1 part by weight of mercury in 2 parts of nitric acid of sp. gr. 1.42 and then diluting with twice its volume of water.

Preservative fluid, prepared by dissolving 20 parts by weight of chrome alum and 5 parts formalin in 975 parts of water. This serves to preserve (although it may discolor) portions of leaves, stems, rootstocks, roots, fruits, etc., which it is desirable to keep in a moist condition, and is much cheaper than alcohol. One part formalin to 40 of water by volume makes a still better preservative

[1] It is cheaper to buy this than to make it.

[2] As considerable quantities of this are to be used (especially if it is issued to the class for home work), if it cannot be bought very cheaply the instructor may make it for himself by dissolving eosin in water. Eosin costs by the pound from $1.65 to $2. An ounce will make as much as two quarts of red ink.

fluid, since it does not alter the natural colors of most objects kept in it.

Pure glycerine.

Glycerine and distilled water, equal parts.

Carbolic acid crystals.

Carbolic acid, 2-per-cent solution.

Iodine solution, prepared by dissolving 4 grams potassium iodide in 40 cubic centimeters distilled water, adding 1 gram iodine, and, when it is entirely dissolved, diluting the solution to 1000 cubic centimeters.

Syrups of various strengths for pollen-tube production, made by dissolving ordinary granulated sugar in boiling-hot distilled water. The water should be weighed cold, then heated in a flask and the weighed amount of sugar added. It will be found less troublesome to weigh out the required amounts in this way than to make a saturated solution and dilute it. Syrups of 2, 5, 10, 15, 25, and 30 per cent sugar will furnish range enough for experiment. If they are kept in glass-stoppered bottles which have been rinsed out with chromic acid solution and then with distilled water, the syrup will keep for months.

Ammonium nitrate, 4-per-cent solution. This may be added in small quantities to potted plants as a fertilizer.

Ether, commercial, for extraction of oil from seeds. (Benzine is cheaper and will answer nearly as well.)

Sand, pine-sawdust, blotting-paper, for germination of seeds. Grafting-wax.

Botanical apparatus and laboratory supplies of every description, including material for study, will be furnished by the Cambridge Botanical Supply Co., 1284 Massachusetts Ave., Cambridge, Mass.

APPENDIX C.

MATERIAL FOR STUDY.

Chapter I. — Squash-seeds, beans, peas, sunflower-seeds.

Chapter II. — Barley, red-clover-seed, seedlings of several kinds, 2–6 inches high, growing in earth, sand, or sawdust.

Chapter III. — Sprouted peas, clover-seed, four-o'clock-seed, Indian corn, boiled green corn in alcohol, bean seedlings 3 weeks old, ground flaxseed, soaked corn, corn meal, flour, oatmeal, buckwheat flour, rye flour, sunflower-seeds, peanuts, Brazil nuts.

Chapter IV. — Cuttings of Wandering Jew (*Tradescantia zebrina*), corn-stalks with roots, water-hyacinth, microscopic sections of roots,[1] parsnips, dahlia roots or sweet potatoes, begonia leaves.

Chapter V. — Twigs of horse-chestnut, hickory, beech, etc., with winter buds, potatoes, onions, rootstocks of iris, sweet flag, or sedges (best in preservative fluid).

Chapter VI. — Apple twigs, fresh or in preservative fluid, hickory or white-oak twigs of three or more years old, set of Hough's thin sections (footnote, p. 53), billets of as many kinds of native wood as are obtainable (with the ends planed smooth and split through the pith), cylinders from three or four year old hickory, or elm twigs, thin sections (see list at end), corn-stalk (in preservative fluid), palmetto, rattan, bamboo, asparagus.

Chapter VII. — Fresh shoots of grapevine, twigs of oak, ash, or elm, fuchsia growing in a flower-pot, microscopic sections (see list at end), potatoes, onions.

Chapter VIII. — Twigs with winter buds of horse-chestnut, hickory, beech, tulip tree, lilac. A cabbage, a Bryophyllum leaf.

Chapter IX. — Leafy twigs of elm and maple, a variety of netted-veined and some parallel-veined leaves.

[1] See list at end of Appendix C.

Chapter X. — Potted plants of oxalis and sensitive plants, sunflower seedlings a foot or more high to show movement of leaves to secure sunlight.

Chapter XI. — Droseras and Sarracenias, potted and growing under bell glass, a cactus, a houseleek or an aloe, an Echeveria or a Cotyledon.

Chapter XII. — Fresh lily leaves, microscopical preparations (see list at end), fresh hydrangea or cucumber leaves, potted hydrangeas and rubber plants (§ 144), leaves of lettuce, hydrangea, maple, hickory, or cucumber (§ 145), Elodea, Fontinalis, Spirogyra, etc. (footnote to § 149), growing nasturtium plants, early summer and late fall leaves of trees in alcohol.

Chapter XIII. — Fresh flowers of any species of Tradescantia, or living Chara or Nitella in water.

Chapter XIV. — Flower-clusters of various kinds.

Chapter XV. — Flowers of trillium, tulip, or buttercup.

Chapter XVI. — Imperfect flowers, as those of willow, poplar, walnut, birch, hazel, begonia.

Chapter XVII. — Fresh pollen of Cytisus, sweet pea, or nasturtium, mounted slide of pollen (see list at end).

Chapter XVIII. — Flowers of hazel, alder, pine grasses (wind-fertilized), insect-fertilized flowers from list in § 211.

Chapter XIX. — Fruits of tomato, lemon, bean, dock.

Chapter XX. — Fruits of ash, elm, or maple, of milkweed, of burdock, cocklebur, or beggar's ticks (*Bidens*), of cherry, or strawberry.[1]

Chapter XXIII. — Protococcus (or Pleurococcus). Living specimens are best, but mounted slides will answer. Living Spirogyra, mounted slides of Spirogyra in conjugation, desmids (fresh or mounted), growing yeast, black mould growing, a mounted slide of zygospores of Mucor, Polytrichum in various stages of growth, a mounted slide of some moss protonema, whole fern plants (including rootstocks), fruiting fern fronds, fern prothallia (fresh, or mounted for the microscope).

[1] Professor Byron D. Halsted, Rutgers College, New Brunswick, New Jersey, will furnish sets of 100 weeds and of 100 weed-seeds and fruits at $10 per set; $20 for the two sets.

List of Slides.[1]

1. Starch in cotyledons of bean.
2. Do. three weeks after germination.
3. Rootlet of "Chinese sacred lily," *Narcissus Tazetta*, variety *orientalis* (longitudinal section).
4. Rootlet of barley.
5.[2] Cross-section of exogenous root in its winter condition (starch).
6.[2] Do. of small parsnip.
7. Cross-section, longitudinal tangential section, and longitudinal radial section of apple wood (all on one slide).
8. Do. of grapevine.
9. Do. of sassafras.
10. Macerated wood cells and bast fibres.
11. Three sections of white pine (on one slide).
12. Longitudinal section of chicory or dandelion root (ducts, parenchyma).
13. Do. rootstock of Pteris (ducts, parenchyma).
14. Do. stem of Ricinus (ducts, parenchyma).
15. Section of elder pith.
16. Cross-section of young stem of clematis.
17. Cross-section of Indian corn stem.
18. [2] Do. of ash or beech twig in winter (storage of starch).
19. Lily leaf, cross-section and under epidermis (one slide).
20. Hydrangea leaf, lower epidermis.
21. *Ficus elastica* cross-section and lower epidermis (one slide).
22. Cross-section of leaf of rhododendron.
23. Cross-section of leaf of beech.
24. Pollen.
25. Protococcus.
26. Spirogyra in conjugation.

[1] This set of thirty-one mounted slides and the accompanying unmounted sections in alcohol will be furnished for $6 (or if mailed for $6.25) by Miss E. M. Drury, 45 Munroe Street, Roxbury (Boston), Mass. The price for single slides in this set varies from 25 to 50 cents per slide; other slides furnished to order.

[2] Fifty thin sections of each of these objects will be furnished in alcohol. They may be soaked in water for a few minutes, then moistened with dilute iodine solution and examined under the microscope for starch.

27. Zygospore formation of *Mucor Syzigites.*
28. Protonema of a moss.
29. Leaf of a moss (Mnium).
30. Prothallium of a fern.
31. Do. beginning to grow a young fern plant.

APPENDIX D.

REFERENCE BOOKS.[1]

Only a few of the books which the author regards as the most useful guides to elementary study and research in their several departments are here named. Both pupil and teacher will find it desirable to consult some of them frequently throughout the whole course of the botanical work. The starred titles (**) indicate books which will aid the teacher, but which the ordinary high-school pupil could hardly use. Where it is possible to discriminate, the best book, that is the book which combines accuracy, fullness, newness, and simplicity of statement to the highest degree, is placed first in its own list.

General Works.

Kerner and Oliver, *Natural History of Plants.* Blackie & Son, London, 1895. Henry Holt & Co., New York, 1895.

Strasburger, Noll, Schenk, and Schimper, *Lehrbuch der Botanik,*** *zweite Auflage.* Gustav Fischer, Jena, 1896.[2]

Vines, *Students' Text-Book of Botany,*** 2 vols. Macmillan & Co., New York, 1895.

Behrens, *Text-Book of General Botany.* Pentland, Edinburgh.

The Kerner and Oliver is a costly book, but is almost indispensable, since it goes over the greater part of the field of botany in a full and accurate, yet thoroughly simple and interesting way. The only criticism that can be urged against it is on the score of occasional fanciful statements, in regard to theories as yet unproved. The work by Strasburger and others is perhaps the best recent

[1] The author has been much aided in the preparation of this list by the one contained in Spalding's *Introduction to Botany.*

[2] A translation of this book will be issued by Macmillan & Co. The author has been obliged in the present book to refer to the second German edition of the *Lehrbuch,* since the English translation is not yet ready.

summary of botany in a moderate-sized octavo volume. Behrens's *Botany* is less recent, but very suggestive. All four books are profusely illustrated.

Laboratory Manuals.

Darwin and Acton, *Practical Physiology of Plants.* Macmillan & Co., New York, 1894.

Detmer, *Das Pflanzen-physiologische Practicum,*** *zweite Auflage.* Fischer, Jena, 1895.

MacDougal, *Experimental Plant Physiology.* Henry Holt & Co., New York, 1895.

Strasburger, *Practical Botany,* Macmillan & Co., New York, 1889; or better, *Kleines Botanisches Practicum,*** *zweite umgearbeitete Auflage,* Fischer, Jena, 1893.

Spalding, *Introduction to Botany.* D. C. Heath & Co., Boston, 1895.

Huxley and Martin, *Elementary Biology* (extended by Howes and Scott). Macmillan & Co., New York, 1892.

Clark, *Practical Methods in Microscopy.* D. C. Heath & Co., Boston, 1897.

Newell, *Outlines of Lessons in Botany,* Part I and Part II (2 vols.). Ginn & Co.

The first three of the books above mentioned are devoted to experiments in vegetable physiology. Detmer's is the best for those who can read German. Strasburger's book is devoted to vegetable histology and is excellent, though the translation by Hillhouse (of Strasburger's larger work) is less satisfactory than the *Kleines Botanisches Practicum.* Spalding's *Introduction* is not wholly a laboratory manual, though largely so. It supplies admirable directions for getting acquainted with plant life and structure at first hand. Huxley's *Biology* is partly devoted to animals, partly to plants. It gives excellent directions for the laboratory study of some of the lower forms of plant life.

Structural and Physiological.

Gray, *Structural Botany.* American Book Co.

Gregory, *Elements of Plant Anatomy.* Ginn & Co., 1895.

De Bary,** *Comparative Anatomy of the Phanerogams and Ferns.* Oxford, Clarendon Press, 1884.

Bessey, *Botany.* Henry Holt & Co., New York, 1888.

Thomé, *Structural and Physiological Botany.* John Wiley & Sons, New York, 1891.

Sachs, *Lectures on The Physiology of Plants.* Macmillan & Co., Oxford, Clarendon Press, 1887.

Gray's *Structural Botany* is written in an exceedingly clear and readable style. It is not brought down to date and it gives little histology; it is well supplemented by De Bary's work, and these two books, with the masterly lectures by Sachs, furnish a very full account of vegetable structure and life. Vines, *Physiology of Plants*, Cambridge, University Press, 1886, is more to be depended on in its chemical statements than the work of Sachs. Either Bessey's or Thomé's book furnishes a brief summary of anatomy and physiology.

Morphological.

Goebel, *Outlines of Classification and Special Morphology of Plants.*** Oxford, Clarendon Press, 1887.

Pax, *Morphologie der Pflanzen.*** Enke, Stuttgart, 1890.

Systematic.

Warming and Potter, *Handbook of Systematic Botany.*** Macmillan & Co., New York, 1895.

Engler and Prantl, *Die Natürlichen Pflanzenfamilien.*** Engelmann, Leipzig.

Le Maout and Decaisne, *Traite Général de Botanique.*** Firmin Didot Frères, Fils & Cie, Paris.

Vines, *Student's Text-Book* (see above).

Strasburger, Noll, Schenk, and Schimper, *Lehrbuch* (see above).

The first-named book in the list is clear, ably written, and sufficient for all ordinary purposes. Engler and Prantl's work in several volumes is a very large and elaborate one, not yet completed, with a wealth of illustrations. Le Maout and Decaisne's treatise is not modern, but is abundantly illustrated and will be found useful.

The work of Vines and that of Strasburger and others both contain outlines of systematic botany.

Floras, Etc.

Gray, *Field, Forest, and Garden Botany.* New edition by L. H. Bailey. American Book Co., 1894.

Gray, *Manual of Botany.* Sixth edition, revised. American Book Co.

Gray, *Synoptical Flora of North America.* American Book Co.

Chapman, *Flora of the Southern United States.* American Book Co.

Coulter, *Manual of the Botany of the Rocky Mountain Region.* American Book Co.

Miller and Whiting, *Wild Flowers of the Northeastern States.* G. P. Putnam's Sons, 1895. (Fully illustrated.)

Sargent, *The Silva of North America*** (in 12 vols., of which 8 have appeared; very fully illustrated). Houghton, Mifflin & Co., Boston.

Cryptogamic Botany.

Eaton, *Ferns of North America.*** Cassino, Boston, 1879.

Underwood, *Our Native Ferns and their Allies.* Henry Holt & Co., New York.

Macdonald, *Microscopical Examination of Drinking Water.* Lindsay and Blakiston, Philadelphia, 1875.

De Bary, *Comparative Morphology and Biology of the Fungi, Mycetozoa, and Bacteria.*** Oxford, Clarendon Press, 1887.

Bennett and Murray, *Handbook of Cryptogamic Botany.* Longmans, Green & Co., London and New York, 1889.

Goebel, *Outlines of Classification*, etc.** (See above.)

Warming and Potter, *Handbook*, etc.** (See above.)

The number of monographs on special topics in cryptogamic botany is too great to admit, in an elementary book, of even the mere mention of the most important titles. In the list above given, the works of Bennett and Murray and of Goebel are the only general ones, and in the former mention is made of a good many of the best special treatises on cryptogamic botany.

Relation of Plants to their Environment.

Müller, *The Fertilization of Flowers.* Macmillan & Co., London, 1883.

Darwin, *Insectivorous Plants.* D. Appleton & Co., New York.

Darwin, *The Power of Movement in Plants.* D. Appleton & Co., New York.

Darwin, *Animals and Plants under Domestication.* D. Appleton & Co., New York.

Geddes, *Chapters in Modern Botany.* Scribners, New York, 1893.

Lubbock, *Flowers, Fruits, and Leaves.* Nature Series, London.

Kerner, *Natural History of Plants.* (See above.)

Wiesner, *Biologie der Pflanzen.*** Wien, 1889.

Ludwig, *Lehrbuch der Pflanzenbiologie.*** Enke, Stuttgart, 1895.

Weed, *Ten New England Blossoms and their Insect Visitors.* Houghton, Mifflin & Co., Boston, 1895.

APPENDIX E.

THE NOTE-BOOK.

A good deal of the effectiveness of any course in botany which includes some laboratory work will depend on the way in which the note-book is kept.

It is better to have two books, one unruled, for drawing, the other ruled, for written notes.[1] All drawings and sketches should be made in such a way as to bring out (as far as the pupil understands them) the characteristic features of the organ or structure which is under investigation. A sketch in which a good deal of detail is omitted will, therefore, often be of more value than one in which the attempt is made to represent everything. Shading is in general to be avoided. The student will need constant admonition not to conventionalize what he sees, or to try to give general impressions. He would, if unguided, very likely represent the cross-section of coniferous wood, magnified 150 or 200 times, by a set of cross-hatchings, with the lines crossing at oblique angles, thus forming a set of very regular, diamond-shaped figures. The best antidote to this tendency is to confront the conventionalizer at every turn with a *camera lucida* drawing of the thing which he has just sketched, or (better still) with a photomicrograph.

The written notes should be kept in an orderly way; and the book which contains them needs to be indexed, day by day, as the work progresses. The writer feels convinced, as the result of a good many years of experience, that it is a mischievous practice to require pupils of secondary-school age to take any notes from rapid dictation. Matter which cannot be furnished in cyclostyle or hektograph copies to every pupil should be dictated orally, very slowly, or else posted

[1] An excellent note-book in which the pages are alternately ruled and blank, as recommended by Prof. W. F. Ganong of Smith College, is furnished by the Cambridge Botanical Supply Co.

on the board, or in a typewritten copy, to which the pupils may have free access during study-hours.

Frequent and unexpected examinations of the note-books by the teacher will do more than anything else to make pupils exact and painstaking in their record of work done. Much importance should be given to the valuation of the note-book in judging of the owner's progress in his work.

It is an unpardonable fault in the teacher to allow the notes to become mechanical, and it is therefore, in the writer's opinion, inadmissible to allow any set form of record to be followed throughout the study of any tissue or organ. The observations of the pupil may well be grouped in an orderly fashion during his first studies of leaves, for example, by following in the record some such form as that given in any of the best plant-analysis blanks, but it would be absurd to stretch the learner on such a Procrustes' bed more than once. It will go far toward training the pupil into a scientific habit of mind if he is required in his notes and in his recitations to distinguish clearly the sources of his knowledge. He should be able to state whether a given piece of information was derived from his own experiment or personal study of an object or a phenomenon, from an experiment performed by the teacher in the presence of the class, from outside reading, or from study of the text-book. Both note-books should throughout present constant evidence of the care with which their owner has kept account of the way in which he became possessed of the subject-matter which he enters in them. Drawings copied from the blackboard or from any book or photograph should be carefully labeled in such a way as to distinguish them from original ones.

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BERGEN'S ELEMENTS OF BOTANY

KEY AND FLORA

SOUTHERN UNITED STATES EDITION

BY

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PART II.

FLORA OF THE SOUTHERN UNITED STATES.

BY

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PREFACE.

This manual is designed for the use of secondary schools in the southeastern part of the United States, from North Carolina southward to Florida and westward to Texas. It does not purport to give all the known flowering plants of that region, but gives the more common species blooming in the early summer before the close of the school year, together with a few of those which are prominent later in the season. In the selection of the species given, only such as may be identified with clearness and certainty have been included; while some, although very common, which are separated from others only by minute and technical differences, have been omitted. The object of the work is not so much to enable the student to name the family, genus, and species of every plant he may find, as to enable him to learn how plants are classified, something of the relations and differences of the more important groups, and the process by which an unknown plant may be identified. The ability to identify and name plants is not the object of botanical study, but it is a great assistance in attaining the knowledge which the true student of botany is seeking — an understanding of the laws of life in the vegetable kingdom.

It is suggested to teachers using this book that they should take pains to secure for class-room study only such plants as are described in the manual, that time may not be wasted and pupils discouraged by efforts to identify species which are too difficult for elementary work. The illustrations are from Bergen's text-book, and are used with the original numbers. In preparing the descriptions living plants have been examined whenever possible, while free use has been made of Chapman's *Flora of the Southern States*, Gray's *Synoptical Flora*, Britton and Brown's *Illustrated Flora*, and other botanical works.

BILOXI, MISS., March 15, 1899.

KEY TO THE FAMILIES OF PHANEROGAMS DESCRIBED IN THIS MANUAL.

CLASS I.

GYMNOSPERMS. Ovules not enclosed in an ovary.

Trees or shrubs; leaves usually evergreen and needle-shaped or scale-like; flowers monœcious or diœcious; fruit a dry or fleshy cone.
1. Pinaceæ.

CLASS II.

ANGIOSPERMS. Ovules enclosed in an ovary.

SUBCLASS 1. — MONOCOTYLEDONS. Flowers usually on the plan of 3, never of 5; leaves usually parallel-veined; cotyledon single.

FLOWERS GLUMACEOUS.

Flowers 2-bracted; leaves 2-ranked; stem cylindrical . . . . . . 4. Gramineæ.
Flowers 1-bracted; leaves 3-ranked; stem triangular . . . . . . 5. Cyperaceæ.

FLOWERS ON A SPADIX.

Spadix spike-like; perianth of bristles . 2. Typhaceæ.
Spadix simple, fleshy . . . . . 7. Araceæ.
Spadix branched . . . . . 6. Sabalaceæ.

FLOWERS NOT ON A SPADIX.

Carpels several, distinct . . . . 3. Alismaceæ.
Carpels united.
Perianth free, or united only to the base of the ovary.
Perianth regular, segments chaffy . . . 11. Juncaceæ.

Perianth regular; in 2 series, the outer sepal-like.	
Epiphytes or parasites	8. Bromeliaceæ.
Terrestrial, petals deliquescent . . .	9. Commelinaceæ.
Terrestrial, petals withering-persistent .	14. Convallariaceæ.
Perianth regular, segments nearly alike, petaloid.	
Fruit capsular.	
Styles distinct or partly united . .	12. Melanthaceæ.
Styles wholly united	13. Liliaceæ.
Fruit berry-like.	
Stems climbing by tendrils . . .	15. Smilaceæ.
Stems not climbing	14. Convallariaceæ.
Perianth irregular.	
Perianth in 2 series, the outer sepal-like .	9. Commelinaceæ.
Perianth in a single series, the segments united	10. Pontederiaceæ.
Perianth adnate to the ovary.	
Stamens with anthers, 1 or 2	19. Orchidaceæ.
Stamens 3, opposite the inner perianth segments	16. Hæmodoraceæ.
Stamens 3, opposite the outer perianth segments	18. Iridaceæ.
Stamens 6	17. Amaryllidaceæ.

SUBCLASS 2. — DICOTYLEDONS. Flowers usually on the plan of 5 or 4; leaves netted-veined; cotyledons 2.

APETALOUS DIVISION. Flowers with no corolla, and sometimes with no calyx.

Flowers monœcious or diœcious, one or both kinds in aments.

Staminate flowers in aments, the pistillate solitary or clustered.	
Leaves pinnately compound	21. Juglandaceæ.
Leaves simple	25. Fagaceæ.
Both staminate and pistillate flowers in aments.	
Leaves alternate.	
Fruits aggregated, fleshy	27. Moraceæ.
Fruit a drupe	22. Myricaceæ.
Fruit a capsule, seeds comose . . .	23. Salicaceæ.
Fruit a nut or samara	24. Betulaceæ.
Leaves opposite, parasitic shrubs . . .	29. Loranthaceæ.

Flowers not in aments, both calyx and corolla wanting.	
Flowers monœcious, in globose heads, trees .	55. Platanaceæ.
Flowers perfect, in slender spikes, herbs . .	20. Saururaceæ.
Flowers not in aments; calyx present, sometimes petaloid.	
Trees or shrubs.	
Ovary inferior	90. Cornaceæ.
Ovary superior.	
Style single, entire, fruit a samara . .	99. Oleaceæ.
Style single, entire, fruit a drupe.	
Anthers opening by valves	44. Lauraceæ.
Anthers opening lengthwise . . .	85. Thymeleaceæ.
Styles 2 or 2-cleft, fruit 1-celled . . .	26. Ulmaceæ.
Styles 2 or 2-cleft, fruit 2-celled . . .	73. Aceraceæ.
Woody twining vines; ovaries 3	42. Menispermaceæ.
Herbs.	
Ovary inferior, 4-celled	87. Onagraceæ.
Ovary inferior, 6-celled	30. Aristolochiaceæ.
Ovary superior, 1-celled.	
Stipules none.	
Stamens numerous	40. Ranunculaceæ.
Stamens few; flowers with scarious bracts	33. Amaranthaceæ.
Stamens few; flowers without bracts .	32. Chenopodiaceæ.
Stipules sheathing the joints	31. Polygonaceæ.
Stipules not sheathing.	
Style single	28. Urticaceæ.
Styles 2	27. Moraceæ.
Ovary superior, 3-celled	68. Euphorbiaceæ.
Ovary superior, 5-celled; fruit a capsule .	51. Crassulaceæ.
Ovary superior, 5–10-celled; fruit a berry .	34. Phytolaccaceæ.

POLYPETALOUS DIVISION. Calyx and corolla both present, the petals not united

A. Stamens more than 10.

Trees, shrubs, or woody vines.	
Leafless, or nearly so; stem fleshy . . .	84. Cactaceæ.
Leaves alternate.	
Ovary one, simple.	
Fruit a drupe	58. Drupaceæ.
Fruit a legume	59. Mimosaceæ.

Ovary one, compound; fruit dry.	
Ovary 1-celled, with 3-5 parietal placentæ	81. Cistaceæ.
Ovary 5-celled, 1-2-seeded at maturity .	77. Tiliaceæ.
Ovary 5-celled, 3-10-seeded at maturity.	
Stamens monadelphous	79. Theaceæ.
Stamens distinct	86. Lythraceæ.
Ovary one, compound; fruit fleshy .	57. Pomaceæ.
Ovaries numerous.	
Leaves stipulate.	
Stamens inserted on the receptacle .	38. Magnoliaceæ.
Stamens inserted on the calyx . .	56. Rosaceæ.
Leaves not stipulate.	
Small trees	39. Anonaceæ.
Woody twining vines	42. Menispermaceæ.
Leaves opposite; fruit dry.	
Ovary single, 1-celled	80. Hypericaceæ.
Ovary single, 3-5-celled	52. Saxifragaceæ.
Ovaries several, enclosed by the calyx tube	43. Calycanthaceæ.
Leaves opposite; fruit fleshy, many-seeded .	86. Lythraceæ.
Herbs.	
Ovary single, simple; fruit a berry . . .	41. Berberidaceæ.
Ovaries several, simple.	
Stamens inserted on the receptacle . .	40. Ranunculaceæ.
Stamens inserted on the calyx	56. Rosaceæ.
Ovary compound.	
Aquatic herbs, leaves flat	37. Nymphæaceæ.
Marsh herbs, leaves tubular	49. Sarraceniaceæ.
Terrestrial herbs.	
Ovary 1-celled.	
Placentæ central, juice watery . .	35. Portulacaceæ.
Placentæ central, juice milky or colored	45. Papaveraceæ.
Placentæ 2, parietal	47. Capparidaceæ.
Placentæ 3-6, parietal.	
Leaves alternate	48. Resedaceæ.
Leaves opposite	80. Hypericaceæ.
Ovary several-celled, stamens monadelphous	78. Malvaceæ.

B. Stamens not more than 10.

Trees, shrubs, or woody vines.
Fruit a drupe.
Stamens 2, rarely 3–4 . . . . . . 99. Oleaceæ.
Stamens as many as the petals.
Flowers diœcious . . . . 42. Menispermaceæ.
Flowers perfect.
Stamens 4, alternate with the petals . 90. Cornaceæ.
Stamens 5, alternate with the petals . 69. Anacardiaceæ.
Stamens 4–5, opposite the petals . . 75. Rhamnaceæ.
Stamens twice as many as the petals . . 66. Meliaceæ.
Fruit a berry.
Stamens alternate with the petals.
Inserted on the calyx, leaves simple . . 53. Grossulariaceæ.
Inserted on the receptacle, leaves compound . . . . 88. Araliaceæ.
Stamens opposite the petals . . . . 76. Vitaceæ.
Fruit a 1-seeded samara . . . . . . 65. Simarubaceæ.
Fruit a 2-seeded capsule or samara.
Leaves simple . . . . 54. Hamamelidaceæ.
Leaves compound . . . . . . 64. Rutaceæ.
Fruit a 3–5-celled capsule, leaves simple . . 72. Celastraceæ.
Fruit a 1–3-celled capsule, leaves compound . 74. Hippocastanaceæ.
Fruit a legume.
Stamens distinct . . . . . . 60. Cæsalpinaceæ.
Stamens monadelphous or diadelphous . 61. Papilionaceæ.
Herbs.
Ovary single, 1-celled, simple or compound.
Corolla regular, or nearly so.
Sepals and petals 4–5; stamens 5, distinct.
Leaves alternate.
Stigma single . . . . . . 60. Cæsalpinaceæ.
Stigmas 4 . . . . 52. Saxifragaceæ.
Stigmas 6–10 . . . . . . 50. Droseraceæ.
Leaves opposite, flowers yellow . . 80. Hypericaceæ.
Leaves opposite, flowers white or red . 36. Caryophyllaceæ.
Sepals and petals 4–5; stamens 5, united 83. Passifloraceæ.
Sepals 2, petals 4–5 . . . . . . 35. Portulacaceæ.
Corolla irregular.
Fruit a legume . . . . . . 61. Papilionaceæ.

Fruit a capsule.	
Stamens 5	82. Violaceæ.
Stamens 6, in 2 sets	45. Papaveraceæ.
Ovary single, 2–5-celled, fruit dry.	
Ovary 2-celled.	
Flowers in umbels, stamens 5	89. Umbelliferæ.
Flowers not in umbels, stamens 6	46. Cruciferæ.
Ovary a 4-celled capsule.	
Calyx adherent to the ovary	87. Onagraceæ.
Calyx enclosing the ovary, but not adherent	86. Melastomaceæ.
Ovary a 5-celled capsule.	
Leaves simple.	
Parasitic, capsule many-seeded	92. Monotropaceæ.
Terrestrial, capsule 5–10-seeded	62. Geraniaceæ.
Leaves trifoliate	63. Oxalidaceæ.
Ovary single, 2–5-celled; fruit a berry	88. Araliaceæ.
Ovaries 2, seeds comose	103. Asclepiadaceæ.

GAMOPETALOUS DIVISION. Calyx and corolla both present, the petals more or less united. may be fused at bottom

Trees, shrubs, or woody vines.	
Leaves alternate.	
Fruit dehiscent.	
Fruit a legume	61. Papilionaceæ.
Fruit a 3-celled capsule	91. Clethraceæ.
Fruit a 5-celled capsule	93. Ericaceæ.
Fruit indehiscent, dry.	
Fruit drupe-like, 1-seeded	97. Symplocaceæ.
Fruit ovoid and winged or globose and 1–2-seeded	98. Styracaceæ.
Fruit 2–3-celled, 2–3-seeded	70. Cyrillaceæ.
Fruit a drupe	71. Ilicaceæ.
Fruit a berry.	
Ovary superior; seeds few, large	96. Ebenaceæ.
Ovary superior; seeds many, small	110. Solanaceæ.
Ovary inferior	94. Vacciniaceæ.
Leaves opposite.	
Fruit a 2-celled, 2-seeded capsule	117. Rubiaceæ.
Fruit a 2-celled, many-seeded capsule.	
Seeds winged	113. Bignoniaceæ.

Seeds not winged; shrubs . . . . . 118. Caprifoliaceæ.
Seeds not winged; twining vines . . 100. Loganiaceæ.
Fruit a 5-celled capsule . . . . . 93. Ericaceæ.
Fruit a drupe or berry.
Fruit 1–2-seeded; stamens 2 . . . 99. Oleaceæ.
Fruit 1–4-seeded; stamens 4 . . . 108. Verbenaceæ.
Fruit 1–5-seeded; stamens 5 . . . 118. Caprifoliaceæ.

Herbs.
Ovary superior, flowers regular.
Ovary separating into 2 distinct follicles.
Style single, stamens distinct . . . 102. Apocynaceæ.
Styles 2, stamens united . . . . 103. Asclepiadaceæ.
Ovary 1-celled.
Fruit a legume . . . . 59. Mimosaceæ.
Fruit a capsule.
Leaves alternate.
Stamens opposite the lobes of the corolla . . . . 95. Primulaceæ.
Stamens alternate with the lobes of the corolla . . . . . . 106. Hydrophyllaceæ.
Leaves opposite . . . . . . 101. Gentianaceæ.
Ovary 2-several-celled.
Stamens 2 or 4 . . . . 116. Plantaginaceæ.
Stamens 5, cells of the ovary 1–2-seeded.
Fruit separating into 4 nutlets . . 107. Boraginaceæ.
Fruit a capsule . . . . . . 104. Convolvulaceæ.
Stamens 5, cells of the ovary several-seeded.
Stigma 1 . . . . 110. Solanaceæ.
Stigmas 2 . . . . 100. Loganiaceæ.
Stigmas 3 . . . . 105. Polemoniaceæ.
Ovary superior, flowers irregular.
Ovary 1-celled.
Fruit a legume . . . . 61. Papilionaceæ.
Fruit a capsule . . . . 112. Lentibulaceæ.
Ovary 2–4-celled.
Cells each 1-seeded. not lobed
Ovary deeply 4-lobed . . . . ~~109~~. Labiatæ.
110
Ovary not deeply lobed.
Stamens 2 or 4 . . . . . 108. Verbenaceæ.
Stamens 8 . . . . 67. Polygalaceæ.

Cells each 2-several-seeded.	
Fruit with a long curved beak . .	114. Martyniaceæ.
Fruit not prominently beaked.	
Corolla lobes imbricated in the bud .	111. Scrophulariaceæ.
Corolla lobes convolute in the bud .	115. Acanthaceæ.
Ovary inferior.	
Flowers in an involucrate head.	
Juice milky	122. Cichoriaceæ.
Juice watery or resinous	123. Compositæ.
Flowers not in heads.	
Stamens 3.	
Leaves alternate	120. Cucurbitaceæ.
Leaves opposite	119. Valerianaceæ.
Stamens 4-5.	
Leaves alternate	121. Campanulaceæ.
Leaves opposite or whorled . . .	117. Rubiaceæ.

CLASS I. GYMNOSPERMÆ.

Plants without a closed ovary, style, or stigma; seeds produced between dry or fleshy scales which are borne in small spikes or clusters, and which form a cone or berry; cotyledons usually three or more.

1. PINACEÆ. PINE FAMILY.

Trees or shrubs; wood of disk-bearing tissue, without ducts; juice resinous; leaves mostly evergreen, filiform, linear or scale-like; flowers monœcious or diœcious, destitute of calyx and corolla; staminate flowers each consisting of a catkin-like spike, the stamens several in a cluster, with scale-like bracts; ovules solitary or several on the upper surface of a scale which usually has a small bract at its base, the scales maturing into a woody or papery cone or a fleshy berry.

I. PINUS.

Trees; leaves of two kinds, the earlier thin, chaffy, and scale-like, the later from the axils of the earlier, 2–5 in a cluster, their bases enclosed in a persistent, scarious sheath, evergreen, needle-like, 1–15 in. long; flowers monœcious; staminate ones clustered at the base of shoots of the present season; the stamen clusters arranged spirally, each in the axil of a scale-like bract; filaments very short; pistillate flowers on twigs of the previous season, in small clusters or sometimes solitary, consisting of deciduous bracts spirally arranged, and in the axil of each bract a scale bearing at its base on the upper surface two ovules; scales becoming thickened and woody, forming a cone at maturity; seeds winged.

1. P. PALUSTRIS Mill. LONG-LEAVED PINE. A large tree; bark thin-scaled, wood very resinous, old trees with only a few spreading

branches near the top; leaves in 3's, 10–15 in. long; sheaths 1–1¼ in. long, crowded near the ends of very scaly twigs; staminate aments 2–3 in. long, bright purple, conspicuous; cones terminal, oblong-conical, 6–10 in. long, diameter 2–3 in. before opening, 4–6 in. when fully opened; scales much thickened at the apex and armed with a short recurved spine at the end. February–March. The most common tree in the pine barrens; wood hard, strong, and durable, especially valuable for floors and inside work.

2. P. Virginiana Mill. Scrub Pine. A small tree, usually 20–30 ft. high, but sometimes much taller; bark of the trunk rough, nearly black; twigs smooth and glaucous; leaves in 2's, 1–2 in. long, rigid, sheaths very short; staminate aments dull yellowish purple, 1 in. long; cones solitary, short peduncled, often reflexed, oblong-conic, about 2 in. long; scales thickened at the apex and armed with a slender straight or recurved prickle. April–May. On dry, sandy soil; wood light, soft, weak, and of little value.

3. P. Tæda L. Loblolly Pine, Oldfield Pine. A large tree; bark very thick and deeply furrowed, becoming flaky with age; twigs scaly; leaves in 3's, 6–10 in. long, slender, very flexible; sheaths ⅔–1 in. long; cones solitary, oblong-conical, 3–5 in. long; scales thickened at the apex, the transverse ridge very prominent and armed with a short, stout, straight, or recurved spine. March–April. Common and often springing up in old fields; trunk containing a large proportion of sap wood; timber of little value for outside work.

II. TAXODIUM.

Trees; leaves spreading so as to appear 2-ranked, deciduous; flowers monœcious, appearing before the leaves; staminate ones numerous, globose; forming long, terminal, drooping, panicled spikes; anthers 2–5-celled; pistillate flowers single or in pairs, bractless, the peltate scales 2-ovuled; cone globose; the very thick woody scales angular, separating at maturity; seeds 3-angled, pyramidal.

T. distichum (L.) Rich. Bald Cypress. A very large tree; bark dark brown, rough, fibrous; many of the twigs deciduous with the leaves; leaves alternate, opposite or whorled, distichous, flat, linear, ½–¾ in. long; cones terminal, globose, about 1 in. in diameter; ends of the scales much thickened, rugose and with a distinct triangular marking. February-March. Common in swamps and on the borders of streams; wood reddish, soft, light; specially valuable for shingles and fence posts, and for boat building.

III. JUNIPERUS.

Trees or shrubs; leaves subulate or scale-like, often both forms on the same tree, evergreen, sessile, opposite or verticillate; flowers diœcious or sometimes monœcious; staminate ones lateral or terminal, of few stamens, oblong or ovoid; pistillate flowers of a few opposite or verticillate fleshy scales, each scale 1–2-ovuled; cone globose, berry-like.

J. VIRGINIANA L. RED CEDAR. A tree with spreading branches and dark brown fibrous bark; leaves opposite or in 3's; all of those on young trees and some of those on older trees subulate and spreading, the others scale-like and closely appressed; aments terminal, berry-like; cones light blue with a distinct bloom, about $\frac{1}{4}$ in. in diameter, 1–2-seeded. March-April. A very common tree; the heart wood reddish, light, strong, fragrant; the principal wood used in the manufacture of lead-pencils.

CLASS II. ANGIOSPERMÆ.

Plants producing seeds in a closed ovary formed from one or more modified leaves; cotyledons 1 or 2.

SUBCLASS I. MONOCOTYLEDONS.

Stems with the fibro-vascular bundles scattered irregularly through the parenchyma mass, not in rings, no distinction between bark, wood, and pith; leaves usually parallel-veined, alternate and entire; parts of the flower usually in 3's or 6's, never in 5's; cotyledon single.

2. TYPHACEÆ. CAT-TAIL FAMILY.

Perennial marsh or aquatic plants; rootstock stout, creeping; stem simple, terete, erect; leaves simple, strap-shaped, sheathing at the base, nerved and striate; flowers monœcious, in a single terminal spike, staminate part of the spike uppermost, each part subtended by spathe-like deciduous bracts;

perianth of fine bristles; staminate flowers sessile; stamens 2–7; filaments connate, subtended by minute bracts; pistillate flowers short-pediceled; ovary 1–2-celled; styles 1–2; fruit small, nutlike.

TYPHA.

Characters of the family.

T. LATIFOLIA L. CAT-TAIL. Stem erect, jointed below, 5–8 ft. high; leaves nearly as long as the stem, about 1 in. wide, reticulated and glaucous; spike cylindrical, dark brown or black; staminate and pistillate portions usually without any interval between them, each 4–8 in. long and about 1 in. in diameter; fruit furrowed. June–August. Common in marshes and shallow ponds.

3. ALISMACEÆ. WATER–PLANTAIN FAMILY.

Annual or perennial marsh herbs, usually with creeping runners or rootstocks; stems scapose; leaves long-petioled, sheathing at the base; petiole rounded; blade nerved, reticulated, or sometimes wanting; flowers in racemes or panicles, perfect, monœcious, or diœcious; pedicels in bracted whorls; sepals 3, persistent, petals 3 or wanting; stamens 6 or more, ovaries few or many, 1-celled, 1-seeded; style short or none; fruit a 1-seeded achene.

I. ALISMA.

Annual or perennial herbs, leaves erect or floating, blades prominently ribbed and reticulated, or even pinnately veined; scapes erect, becoming longer than the leaves, terete, spongy; flowers perfect, in paniculate 3-bracted umbels, small, white or pink; stamens 6–9; ovaries numerous in one or more whorls on a flat receptacle; fruit 1-seeded achenes which are ribbed on the back and sides.

A. PLANTAGO-AQUATICA L. WATER PLANTAIN. Perennial; root fibrous; leaves ovate or somewhat cordate, 5–7-nerved when erect, floating leaves narrower and sometimes linear; scapes usually single; panicle 1–2 ft. long; flowering branches whorled, subtended by three narrow, striate bracts; pedicels slender, elongated; ovaries

15–20 in a single whorl; base of the short style persistent, forming a beak at the inner angle of the achene; achenes obliquely obovate, 2–3-keeled on the back. June–September. Common in ponds and muddy places.

II. SAGITTARIA.

Perennial; rootstocks mostly nodose or tuber-bearing; scapes erect or decumbent; leaves long-petioled, sheathing at the base, the blade nerved and reticulated or wanting; flowers monœcious or diœcious, racemed in 3-bracted whorls of 3's, the upper flowers usually staminate; sepals 3, persistent; petals 3, withering-persistent or deciduous; stamens few or many; ovaries in globose heads, 1-ovuled; style short, persistent; fruit a subglobose head of flattened achenes.

1. S. LATIFOLIA Willd. BROAD-LEAVED ARROWHEAD. Leaves very variable in size and shape, from broadly sagittate to linear; those growing on the drier soil being usually the broader; petioles 6–30 in. long, scape smooth or slightly pubescent, 6–36 in. high; bracts acute; flowers monœcious or sometimes diœcious, white, 1 in. or more in width; pedicels of the staminate flowers twice the length of those of the fertile flowers; filaments long, smooth, and slender; achenes compressed, obovate, winged; beak nearly horizontal. June–September. Ditches and muddy places.

2. S. GRAMINEA Michx. GRASS-LEAVED SAGITTARIA. Leaves long-petioled, lanceolate, or elliptical, and acute at each end, 3–5-nerved, or often linear, the earlier often reduced to phyllodia; scape slender, usually longer than the leaves, simple, weak, often prostrate in fruit; bracts small, ovate, connate at the base; flowers monœcious or diœcious, on long, filiform pedicels, about ½ in. wide; stamens 10–20, filaments pubescent, achenes obovate, wing-keeled, nearly beakless. May–October. In ditches and shallow pools.

4. GRAMINEÆ. GRASS FAMILY.

Annual or perennial herbs, sometimes slender trees; stems rounded, often grooved on one side, usually hollow, closed and enlarged at the nodes; leaves 2-ranked, with sheathing bases which are usually split on the side opposite the blade but are sometimes entire, the orifice of the sheath usually crowned with a scarious ring called a ligule; inflorescence in

spikes, racemes, or panicles; flowers in spikelets consisting of 2-ranked imbricated scales or glumes, the two lower usually empty, the others subtending the flower which is enclosed in a scale-like palet; the upper flower in the spikelet often staminate or only an empty palet, or even an abortive pedicel; flowers perfect or monœcious, rarely diœcious; stamens 1–6, usually 3; ovule 1; styles 1–3, usually 2; seed a caryopsis or grain.

A large family, of which there are more than 800 species in the United States, including corn, wheat, rye, oats, rice, sorghum, sugar cane, and many other cultivated sorts. The cane, *Arundinaria macrosperma*, is the only tree-like species found in this country.

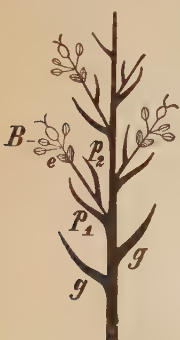

FIG. 210. — Diagram of Inflorescence of a Grass.
g, sterile glumes; P_1, a flowering glume; P_2, a scaly bract (palet); *e*, transparent scales (lodicules) at the base of the flower; *B*, the flower.

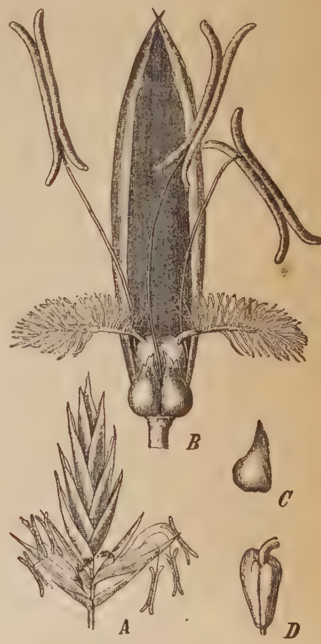

FIG. 211. — Fescue-Grass (*Festuca pratensis*).
A, spikelet (compare Fig. 210); *B*, a flower, the lodicules in front and the palea behind; *C*, a lodicule; *D*, ovary.

[The identification of the species is too difficult for the beginner, but the structure of the spikelets and the separate flowers may be learned by a study of Figs. 210, 211.]

5. CYPERACEÆ. SEDGE FAMILY.

Annual or perennial herbs; grass-like or rush-like; stems mostly 3-angled, solid, leaves 3-ranked, grass-like, with closed sheaths; flowers in spikes or spikelets, perfect or imperfect,

FIG. 212.—Inflorescence, Flower and Seed of a Sedge.
(Great Bulrush, *Scirpus lacustris*.)

1, magnified flower, surrounded by a perianth of hypogynous bristles; 2, the seed; 3, section of the seed, showing the small embryo enclosed in the base of the albumen.

each in the axil of a scale-like bract; perianth often a row of minute scales or bristles; stamens usually 3; ovary 1-celled, style 2–3-cleft or rarely simple; fruit a flattened or 3-angled achene.

A large family, mostly growing in tufts in wet places, few species being of any value. Fig. 212 shows a common form of inflorescence, and an achene with its perianth of bristles.

6. SABALACEÆ. PALM FAMILY.

Trees or plants with woody creeping stems or nearly acaulescent, leaves petioled, pinnate or palmate, plaited in the bud, flowers perfect or polygamous, on a spadix which is often branching or paniculate; sepals and petals 3, more or less united, persistent; stamens usually 6; ovary 3-celled, 3-ovuled; styles 3, distinct or united, stigma entire, fruit a drupe or berry.

I. SABAL.

Stem short, erect, or decumbent, usually simple; leaves long-petioled, nearly orbicular in outline, deeply parted, the divisions 2-cleft at the apex and often with thread-like filaments in the sinuses; sheaths of the leaves usually of dry interlaced fibers; spadix long and branching, with sheathing spathes at the joints; flowers perfect, sessile, each in the axil of a small bract; perianth cup-shaped; petals distinct; stamens 6, filaments distinct; styles 3, united, 3-angled; stigma capitate, fruit a drupe.

S. Andersonii Guerns. Dwarf Palmetto. Stem short, mostly buried in the earth; leaves orbicular, glaucous, divisions slightly cleft at the apex, filaments few; petiole usually shorter than the leaf, crescent-shaped in cross-section, edges smooth; spadix erect, slender, taller than the leaves, 4–6 ft. high, paniculately much branched; drupe black, globose, $\frac{1}{3}$ in. in diameter. June–July. Low grounds, Central Louisiana to North Carolina and southward.

II. SERENOA.

Stems creeping, widely branched; leaves orbicular, long-petioled, at the apex of the branches, divisions slightly cleft at the apex, thread-like filaments none; spadix short, flowers perfect, sessile, bracted; petals slightly united; stamens 6, distinct; style slender; fruit a drupe.

S. SERRULATA B. & H. SAW PALMETTO. Stems creeping widely, often covering spaces 20 ft. in diameter; leaves bright green; petiole plano-convex in cross-section, toothed on the edges; spadix much shorter than the leaves, densely tomentose; style slender; drupe ovoid or oblong, black, $\frac{2}{3}$–$\frac{3}{4}$ in. long. May–July. On sandy soil near the coast.

III. RAPHIDOPHYLLA.

Stem short, thick, erect; leaves long-petioled, fan-shaped, deeply palmately divided, without filaments in the sinuses; sheath persistent, soon dry and net-like, with numerous strong, erect, black spines; spadix branched, densely flowered; spathes 2–4-leaved; flowers yellowish, bracted; calyx 3-cleft; petals distinct; stamens 6–9, united at the base; ovaries 3, more or less united; drupes 1–3, 1-seeded.

R. HYSTRIX W. & D. BLUE PALMETTO. Stem short, erect, often proliferous; leaves triangular, fan-shaped to orbicular, very deeply cleft, the divisions 2–4-toothed, blue-glaucous; petioles mostly longer than the leaves, triangular in cross-section, rough-edged above; spadix small, short-peduncled, widely branched, 6–12 in. long; spathes woolly, partial spathes none; fruit an ovoid drupe, $\frac{1}{2}$–$\frac{3}{4}$ in. long. June–July. Low, shady woods. Central Mississippi to South Carolina and southward.

7. ARACEÆ. ARUM FAMILY.

Perennial herbs, mostly acaulescent, growing from a corm or a creeping rootstock; juice acrid; leaves simple or compound, usually long-petioled and netted-veined, but sometimes strap-shaped and parallel-veined; flowers on a spadix, generally enclosed in a spathe, usually the staminate above and the pistillate below, but in some species perfect or diœcious; calyx and corolla wanting or the former of 4–6 small scales; stamens 4–10, short; ovary 1–several-celled, 1–several ovules in each cell; stigma sessile; fruit indehiscent, a berry or utricle.

I. ARISÆMA.

Corms very acrid, black; leaves usually 1–3, palmately divided; petioles long and sheathing the scape which bears

the spadix at its summit; spathe convolute below, usually dilated and arched above, withering persistent; spadix bearing the monœcious or diœcious flowers at its base, the apex sterile and naked; perianth none; stamens 4 in a whorl, nearly sessile; ovaries 1-celled, 1–6-ovuled; stigma sessile; fruit a 1–few-seeded red berry.

1. A. TRIPHYLLUM (L.) Torr. INDIAN TURNIP. Leaves 2, trifoliate, leaflets sessile, oval or ovate, acuminate, entire, netted-veined; petioles and scape 1–1½ ft. high; flowers monœcious or diœcious; spathe dilated above, arched over the top of the spadix, green with purple stripes on the inside; spadix club-shaped, floriferous below; stamens very short; ovaries crowded, ovules 4–6; fruit bright scarlet, forming an ovoid head about 1 in. long. March–April. In rich woods.

2. A. DRACONTIUM (L.) Schott. DRAGON ROOT. Corms several; leaf usually solitary, petiole 1–3 ft. high, enclosed by membranous sheaths, leaf pedately divided into 7–15 segments which are nearly or quite sessile, oblong or oblanceolate, usually acute at the apex, entire or the lower ones lobed; scape sheathed at the base, usually shorter than the petiole; spathe light green, convolute, acuminate, 1–2 in. long; spadix slender, tapering to a slender point, 4–7 in. long, flower-bearing only in the part enclosed by the spathe; fruit reddish orange, 1–3-seeded, in a large ovoid head. March–April. In rich woods.

II. PELTANDRA.

Perennial marsh herbs with creeping rootstocks; leaves sagittate, acute, entire, the base of the petioles sheathing the rootstock; scape shorter than the petiole; spathe elongated, thick and fleshy; flowers monœcious, covering the entire spadix, staminate flowers above; perianth none; stamens 5–10, imbedded in a peltate, shield-like connective which finally shrivels so as to leave the anthers free; ovaries imbedded in the spadix, surrounded by a few abortive stamens; ovules 1 or few; style short; stigma capitate; fruit 1–3-seeded, green or red berries forming a globose head partially enclosed by the base of the spathe; seeds enclosed in a gelatinous coating.

P. VIRGINICA (L.) Kunth. GREEN ARROW-ARUM. Leaves several, sometimes 2 ft. long, prominently and finely veined with 2–3 intra-marginal nerves; scape nearly as long as the petiole, recurved

in fruit; spathe green, lanceolate, convolute its entire length, longer than the spadix, the upper part withering; berries green, 1-seeded. April–May. In marshes and wet woods.

III. ORONTIUM.

Perennial aquatic herbs, with stout rootstocks buried in the mud; leaves petioled, oval, entire, nerved; spathe enclosing the spadix only in the bud, soon deciduous; flowers perfect, yellow, covering the entire spadix; sepals 4–6, scale-like; stamens 4–6; ovary 1-celled, 1-ovuled, stigma sessile; fruit a green utricle.

O. AQUATICUM L. GOLDEN CLUB. Leaves ascending or floating, very dark green and velvety-looking above, paler beneath, petioles stout, 6–18 in. long; scape stout, thickened above, curved, about as long as the petiole; flowers bright yellow; utricle depressed-globose, tuberculate above. March–April. In slow-flowing streams and shallow ponds.

8. BROMELIACEÆ. PINE-APPLE FAMILY.

Herbs, mostly epiphytic or partly parasitic; whole plant scurfy; stem rigid or flexuous; leaves very slender, often rigid; flowers perfect, regular, spiked, panicled or solitary, bracted; sepals 3, distinct or united; petals 3, distinct or united; stamens 6; ovary superior or inferior, 3-celled, placentæ central, style 1, stigmas 3; fruit fleshy or a 3-celled, 3-valved, many-seeded capsule.

TILLANDSIA.

Epiphytic or partly parasitic herbs; stem rigid and erect or filiform and pendulous; leaves slender, often filiform; sepals rigid; petals spreading above, claw long; stamens filiform, hypogynous; ovary free, style slender; fruit a 3-valved, many-seeded capsule.

T. USNEOIDES L. SPANISH MOSS. Perennial, epiphytic or partly parasitic; stem filiform, branching, gray-scurfy, with a black core like horsehair, 2–10 ft. long; leaves filiform, alternate in small fas-

cicles, sheathing at the base; flowers axillary with conspicuous bracts; sepals distinct or nearly so, green; petals distinct, linear, recurved, greenish-yellow; capsule linear, about 1 in. long, splitting into 3 valves; seeds on a long funiculus which at maturity splits in a coma-like tuft. June–September. On living trees, more common southward. The hair-like core of the stem often used as a substitute for curled hair in making mattresses, cushions, etc.

9. COMMELINACEÆ. SPIDERWORT FAMILY.

Annual or perennial herbs, with viscid or mucilaginous juice; stems somewhat succulent, jointed, leafy, simple or branched; leaves simple, succulent, narrow, entire, sheathing at the base, sheaths entire or split; flowers in terminal cymes or umbels, perfect, often irregular; sepals 3, persistent, foliaceous or colored; petals 3, fugacious or deliquescent; stamens 6 or fewer, often some of them abortive; ovary free, 2–3-celled, style single, stigma entire or 3-lobed; fruit a 2–3-celled, 2–3-valved capsule; seeds solitary or several in each cell.

I. COMMELINA.

Annual or perennial; stem branching, erect or procumbent, smooth or pubescent; leaves petioled or sessile, entire, the floral ones cordate, folded and forming a spathe enclosing the base of the cyme; flowers irregular; sepals mostly colored, 1 of them smaller; petals blue, unequal, 2 of them reniform and long-clawed, the other smaller; stamens 6, only 3 of them fertile, filaments smooth; capsule 1–3-celled; seeds 1–2 in each cell.

1. C. HIRTELLA Vahl. BEARDED DAYFLOWER. Stem stout, erect, 2–3 ft. high; leaves lanceolate or oblong, acuminate, rough-hairy above, sheaths $\frac{3}{4}$–1 in. long, fringed with brown hairs; spathes numerous, sessile or short-stalked; petals nearly alike, the odd one smaller; capsule 5-seeded; seeds brown, smooth. August–September. In moist and shaded soil.

2. C. VIRGINICA L. VIRGINIA DAYFLOWER. Stem erect, pubescent, 1–2 ft. high; leaves lanceolate to oblong-lanceolate, acuminate, 3–5 in. long, somewhat rough above, sheaths inflated, hairy, the orifice often fringed; spathes containing a viscid secretion; flowers

1 in. wide, the odd petal lanceolate; capsule 3-seeded, the dorsal cell indehiscent. May–September. On moist sandy soil.

II. TRADESCANTIA.

Perennial; stem simple or branched; leaves very narrow; flowers in terminal and axillary bracted umbels, regular, 1 in. broad; sepals 3, herbaceous; petals 3, fugacious or deliquescent; stamens 6, sometimes 3 shorter than the others, filaments bearded or smooth; ovary 3-celled, with 2 ovules in each cell; pedicels recurved in fruit; capsule 3-celled, 3-valved, 3–6-seeded.

1. T. Virginica L. Spiderwort. Stem erect, stout, smooth or villous, 1–2 ft. high; leaves linear, keeled, often purple-veined, long-acuminate, 1 ft. or more in length; bracts similar to the leaves, umbels sessile, 2–many-flowered, flowers in 2 rows in the bud; petals blue or purple, twice as long as the sepals; stamens blue, filaments densely bearded; capsule ovoid or oblong. March–June. On dry sandy soil.

2. T. pilosa Lehm. Hairy Spiderwort. Stem stout, erect or flexuous, branched, villous or nearly smooth, 1–2 ft. high; leaves linear-oblong, acuminate at the apex, narrowed at the base, pubescent on both sides; umbels axillary and terminal, many-flowered; pedicels and sepals villous with glandular hairs; flowers blue or purple, $\frac{3}{4}$–1 in. wide; seeds pitted. May–July. In rich soil.

10. PONTEDERIACEÆ. PICKEREL-WEED FAMILY.

Perennial marsh or aquatic herbs; stems simple or branched, succulent; leaves simple, alternate; flowers solitary or spiked, each subtended by a leaf-like spathe, perfect, mostly irregular, perianth corolla-like, 6-parted; stamens 3 or 6, unequal, inserted irregularly in the tube or throat of the perianth; ovary free, style single, stigma entire or toothed; ovary 1- or 3-celled; fruit a 1-seeded utricle.

PONTEDERIA.

Stem erect, from a thick creeping rhizome, bearing a single leaf above the middle and several sheathing bract-like leaves

at its base, radical leaves numerous, thick, parallel-veined; petiole long, from a sheathing base; flowers in terminal spikes, perianth 2-lipped, lobes of the upper lip ovate, of the lower, oblong, spreading; stamens 6, the three upper short and often imperfect, the three lower exserted; ovary 3-celled, but only 1 cell ovule-bearing; the 1-seeded utricle enclosed by the base of the perianth.

P. CORDATA L. PICKEREL-WEED. Stem stout, erect, 2–4 ft. high; leaves long, from cordate to lanceolate and often hastate, apex and basal lobes obtuse, finely nerved; spike dense, 2–4 in. long, peduncles enclosed by the spathe; perianth hairy, blue, the upper lip with two yellow spots, tube 6-ribbed, curved, rather longer than the lobes; ovary oblong. June–September. In ponds and slow streams.

11. JUNCACEÆ. RUSH FAMILY.

Grass-like perennial or annual herbs, mostly growing on wet soil; stems mostly erect but sometimes creeping, simple or branched, naked or leafy and jointed; leaves terete, sheathing at the base, very slender and pointed or flattened and grass-like; flowers in cymes or panicles which may be very loose and spreading, or so compact as to form a head, sometimes with a rigid scape prolonged beyond the flower cluster; flowers usually bracted, perianth of 6 nearly equal scale-like persistent divisions; stamens 3 or 6, inserted on the base of the perianth; ovary free, 1- or 3-celled, many-ovuled, style single, stigmas 3, usually hairy; fruit a 1- or 3-celled, 3–many-seeded capsule.

[Most species flower late in the season, and their identification is too difficult for one without considerable experience.]

12. MELANTHACEÆ. COLCHICUM FAMILY.

Perennial herbs, usually from a stout rootstock; stem simple or branched, leafy; leaves parallel-veined, often with transverse veins, broad or narrow and grass-like; flowers solitary,

racemose, or panicled, regular, perfect, polygamous, or diœcious, perianth of 6 similar and usually distinct segments; stamens 6, rarely 9–12, inserted on the base of the perianth; ovary free or nearly so, 3-celled, many-ovuled, styles 3, distinct or partly united; fruit a capsule, seeds usually winged or tailed.

I. CHAMÆLIRIUM.

Rootstock short and thick, bitter; stem simple, erect, leafy, glabrous; lower leaves spatulate to obovate, the stem leaves narrower; flowers small, white, in a spike-like raceme, diœcious, perianth of 6 linear-spatulate segments; stamens 6, filaments longer than the perianth; ovary 3-celled, styles 3; fruit an ovoid, 3-angled, many-seeded capsule.

C. luteum (L.) Gray. Unicorn-root. Stem furrowed, staminate plants 1–2 ft. high, pistillate taller, often 3 ft. or more; lower leaves obovate, clustered, the upper small and bract-like; staminate racemes slender and drooping, the pistillate erect; flowers short pediceled; capsule 3-valved, seeds linear-oblong, winged at the ends. May–June. On low ground.

II. CHROSPERMA.

Stem simple, glabrous, erect from a bulbous base; leaves long and slender; flowers white, in a simple terminal raceme, perfect, perianth of 6 segments which are sessile and glandless; stamens 6, inserted in the base of the perianth; ovary 3-lobed, 3-celled; fruit a dehiscent 3-lobed capsule, the lobes becoming subulate by the persistent style bases; cells few-seeded.

C. muscætoxicum (Walt.) Kuntze. Fly Poison. Bulb ovoid or oblong; stem somewhat angled below, 1–3 ft. high; lower leaves strap-shaped, channeled, the upper small and bract-like; raceme dense, cylindrical; pedicels from the axils of minute ovate bracts, perianth segments ovate, white, becoming greenish, nearly as long as the slender stamens; styles spreading; capsule with divergent lobes; seeds ovoid, red. May–June. In rich woods.

III. UVULARIA.

Stem slender, branching, erect from a slender, creeping rootstock; leaves alternate, sessile, or perfoliate; flowers terminal, usually solitary, peduncled, drooping, perianth bell-shaped or funnelform, segments 6, distinct, with nectar-bearing glands at the base within, deciduous; stamens 6, short; ovary 3-lobed, 3-celled, style deeply 3-parted, stigmas spreading; fruit a 3-angled or 3-winged, dehiscent capsule, seeds 1–3 in each cell.

1. U. PERFOLIATA L. PERFOLIATE BELLWORT. Stem glabrous, pale green, forked or branched above the middle, 10–20 in. high; leaves ovate or oblong, acute at the apex, perfoliate at the base, entire, glaucous beneath, the sides revolute when young; flowers pale yellow, about 1 in. long, segments lanceolate, granular-roughened within; stamens about the length of the style; capsule obovoid, truncate, the angles grooved. April–May. In moist woods.

2. U. GRANDIFLORA Smith. LARGE-FLOWERED BELLWORT. Stem slender, nearly leafless below the fork, glabrous, 12–24 in. high; leaves ovate or oblong, acute at the apex, perfoliate at the base, entire, smooth above, pubescent below; flowers bright yellow, $1\frac{1}{4}$ in. long, segments linear-lanceolate, smooth within; stamens longer than the styles; capsule obovate, truncate, obtusely angled. April–May. In rich woods. More common northward.

3. U. SESSILIFOLIA L. SESSILE-LEAVED BELLWORT. Stem slender, erect, glabrous, few-leaved below the fork, 6–12 in. high; leaves lanceolate-oblong, thin, acute at each end, margins rough, smooth on both sides, sessile; flowers greenish-yellow, $\frac{3}{4}$ in. long, perianth segments lanceolate, obtuse, smooth within; stamens shorter than the style; capsule stalked, wing-angled. April–May. In rich woods.

13. LILIACEÆ. LILY FAMILY.

Herbs, or woody plants, the herbaceous species mostly from bulbs or corms; leaves sessile or sheathing, parallel-nerved, but often with netted veins; flowers clustered or solitary, perfect, regular; perianth corolla-like, 6-parted, rarely 4-parted, the segments distinct or partially united into a tube; stamens 6, hypogynous or perigynous; ovary 3-celled, many-ovuled,

style 1, stigmas 3, distinct or united; fruit a capsule or berry, few–many-seeded.

Plants from fibrous roots.	
Stem herbaceous.	
Flowers in corymbs or panicles . .	I. Hemerocallis.
Flowers in spikes	VII. Aletris.
Stem woody	VIII. Yucca.
Plants from corms	V. Erythronium.
Plants from bulbs.	
Bulbs coated.	
Flowers in umbels	II. Allium.
Flowers in corymbs	VI. Ornithogalum.
Bulbs scaly.	
Flowers solitary or in corymbs . .	IV. Lilium.
Flowers in spikes	III. Hyacinthus.

I. HEMEROCALLIS.

Perennial, from a fascicle of fleshy roots; stem erect, branched, glabrous; leaves mostly basal and linear; flowers on branching scapes, large, yellow or orange, solitary or corymbed, perianth funnelform with a spreading limb much longer than the tube; stamens 6, inserted in the top of the tube, shorter than the lobes, curved upward; ovary 3-celled, many-ovuled, style longer than the stamens, curved upward, stigma capitate; fruit a 3-celled, 3-angled capsule.

H. FULVA L. DAY LILY. Scapes stout, branched above, with a few bract-like leaves, smooth, 3–5 ft. high; leaves very long, strap-shaped, acute, channeled; flowers short-pediceled, tawny-yellow, perianth lobes oblong, netted-veined, flowers lasting only one day. May–June. Introduced from Asia and common in old gardens.

II. ALLIUM.

Acaulescent herbs from coated bulbous roots with the characteristic odor of onions; bulbs solitary or clustered; leaves narrowly linear or slender-tubular, glaucous; flowers in terminal umbels on naked scapes, the umbels often bracted or enclosed in a spathe, flowers small on slender pedicels, perianth 6-parted, persistent; stamens 6, inserted on the base

of the perianth, filaments filiform or dilated below; ovary sessile, 3-celled, style filiform, jointed, stigma entire; fruit a 3-celled, 3-valved, few-seeded capsule. Flowers sometimes changed into bulblets.

1. A. Canadense L. Meadow Garlic. Bulbs ovoid, the outer coats of white and scarious reticulating fibers; leaves narrowly linear, flat, or concave above; scape terete, 1 ft. high; bracts of the umbel 2–3, ovate, acuminate; umbel consisting mostly of sessile bulblets; the few flowers long-pediceled, rose-colored; perianth about as long as the stamens, filaments dilated below; capsule shorter than the perianth, 6-toothed, seeds 2 in each cell. May–June. On moist soil.

2. A. mutabile Michx. Wild Onion. Bulbs ovoid, solitary, or clustered, outer coat a network of slender fibers; leaves very narrow, concave; scape erect, longer than the leaves, 1 ft. high; umbel erect, many-flowered, bulblets few, bracts 3; perianth white or rose-colored, the segments acute, as long as the stamens; capsule shorter than the perianth, not toothed, seeds 2 in each cell. March–June. In dry, sandy soil.

3. A. striatum Jacq. Striped Wild Onion. Bulbs clustered, outer coat membranaceous; leaves linear, concave, striate on the back; scape 6–12 in. high; umbel 3–10-flowered, bracts 2, pedicels 1–2 in. long; perianth nearly white, longer than the stamens, the outer segments green-keeled on the back; capsule not toothed, seeds several in each cell. March–April. Low pine barrens.

III. HYACINTHUS.

Acaulescent herbs from coated bulbs; leaves linear, fleshy; flowers in an erect spike, pediceled, bracted, perianth tubular below, lobed and spreading above; stamens short, included; style short, stigma capitate, ovary 3-celled, many-ovuled.

H. orientalis L. Hyacinth. Leaves lance-linear, thick and fleshy, smooth; scape erect, many-flowered; segments united about half their length, white, blue, or red; filaments very short; ovary rarely maturing seed. January–March. Common in cultivation.

IV. LILIUM.

Perennial from scaly bulbs; stem erect, leafy, usually tall and slender; leaves sessile, scattered or whorled; flowers

large, erect, or drooping, perianth corolla-like, deciduous, segments 6, spreading or recurved above, sessile or clawed, each with a nectariferous groove near the base; stamens 6, elongated, anthers linear, versatile; ovary 3-celled, many-ovuled, style long and slender, stigma 3-lobed; fruit a 3-celled, dehiscent, many-seeded capsule.

1. L. Catesbæi Walt. Southern Red Lily. Bulbs small, scales narrow, leaf-bearing; stem slender, 1–2 ft. high; leaves scattered, linear, or linear-lanceolate, obscurely nerved, 1–2 in. long; flowers solitary, terminal, scarlet with yellow and purple markings, segments lanceolate, acute, spreading, wavy-margined, long-clawed, the margins of the claws involute; capsule oblong, nearly terete. July–August. Low pine barrens.

2. L. Carolinianum Michx. Carolina Lily. Bulbs globose, on short rootstocks, scales fleshy; stem slender, 2–3 ft. high; leaves scattered or sometimes whorled, oval, or oblanceolate, acute or obtuse at the apex, narrowed below, faintly 3-nerved; flowers 1–3, nodding on long peduncles, perianth segments orange-red and purple-spotted, lanceolate, acute, the edges involute, strongly recurved; capsule obovoid. June–July. In dry woods.

3. L. tigrinum Andr. Tiger Lily. Bulb solitary, large, scales lanceolate, fleshy; stem erect, stout, often purple or black, smooth below, pubescent above, 2–5 ft. high; leaves very numerous, alternate, smooth, or slightly pubescent, 5-nerved, often with black or purplish bulblets in the axils; flowers numerous, orange-red with black or purple spots, nodding, segments lanceolate, pubescent, strongly recurved. May–August. Introduced from China and common in gardens.

V. ERYTHRONIUM.

Low herbs, from scaly corms; stem simple, bearing 2 unequal leaves below the middle; flowers solitary, white or yellow, nodding, bractless, perianth segments 6, distinct, lanceolate, or oblong, spreading, with a nectariferous groove, deciduous; stamens 6, slender, shorter than the perianth; ovary sessile, 3-celled, many-ovuled, style slender, thickened above, 3-lobed; fruit a 3-angled capsule.

E. Americanum Ker. Yellow Dog-tooth Violet. Corm deep in the ground, thus making the leaves often appear radical; leaves elliptical or oblanceolate, thick, acute at each end, entire, smooth, usually mottled with light and dark green, and purple;

peduncle about as long as the leaves; flowers 1 in. long, yellow, sometimes spotted with purple, the 3 inner perianth segments 2-toothed at the base; style club-shaped, capsule obovate, seeds ovoid, with a membranous appendage at the apex. February–March. In rich woods.

VI. ORNITHOGALUM.

Acaulescent herbs from coated bulbs; leaves linear, fleshy; scape erect; flowers in corymbs or racemes, bracted; perianth segments 6, white, nerved, persistent; stamens 6, hypogynous, slender, filaments flattened; ovary sessile, 3-celled, few-ovuled, fruit a roundish, 3-angled capsule, seeds black.

O. UMBELLATUM L. STAR OF BETHLEHEM. Bulb ovoid, membranous-coated; leaves numerous, linear, fleshy, as long as the scape, mid-vein nearly white; scape slender, 6–12 in. high; flowers opening in sunshine, long-pediceled; bracts linear-lanceolate, about as long as the pedicels; perianth segments oblong-lanceolate, white with a green stripe on the back, twice the length of the stamens. April–June. Introduced from Europe; very common about old gardens.

VII. ALETRIS.

Perennial from fibrous and bitter roots; stems erect and scape-like; basal leaves in a rosulate cluster, lanceolate; stem leaves small and bract-like; flowers in a terminal, bracted spike; perianth oblong or tubular, rough and viscid without, smooth within, 6-parted, the tube adherent to the ovary; stamens 6, short, included, inserted at the top of the tube; ovary 3-celled, many-ovuled, style subulate, persistent, stigmas 3, fruit an ovoid, 3-celled, many-seeded capsule, seeds ovate, ribbed.

1. A. FARINOSA L. COLIC-ROOT. Basal leaves numerous, lanceolate or elliptical, acuminate at the apex, sessile, pale yellowish-green; stem scape-like, furrowed or striate, 2–3 ft. high; spike rigid, 4–12 in. long, flowers pediceled, bracted, perianth cylindrical, white, or the spreading lobes yellowish; style slender, 3-cleft, capsule ovoid, longer than the perianth. May–June. On damp pine barrens.

2. A. AUREA Walt. YELLOW COLIC-ROOT. Basal leaves numerous, ovate-lanceolate, very acute, narrowed into a short petiole; stem nearly smooth, 2–3 ft. high; raceme 1–2 ft. long, slender; flowers

scattered, pedicels very short, perianth yellow, globose-ovate, with broad obtuse lobes; style short, obscurely 3-cleft, capsule ovate, about as long as the perianth. May–June. Low, sandy soil.

VIII. YUCCA.

Plants with woody and leafy stems, leaves numerous, rigid, spine-pointed, persistent; flowers in large terminal racemes or panicles, bracted, nodding; perianth campanulate or bell-shaped, segments 6, nearly alike, deciduous; stamens 6, filaments thickened above, often papillose, anthers small; ovary sessile, 3-celled, or becoming 6-celled, 3-angled, many-ovuled, fruit an oblong, 3-angled, many-seeded, dehiscent capsule, or fleshy and indehiscent.

1. Y. ALOIFOLIA L. ALOE-LEAVED YUCCA. Stem erect, 3–6 in. in diameter, branched, rough with the transverse leaf-scars, 4-8 ft. high; leaves rigid, linear-lanceolate, strongly spine-pointed, rough on the margin, the older leaves reflexed; panicle short, smooth, densely flowered, 12–18 in. long; perianth white, sometimes tinged with purple; capsule pulpy, 6-angled, indehiscent. May–June. On sandy soil, more common near the coast.

2. Y. FILAMENTOSA L. SPANISH DAGGER. Stem stout, 4–12 in. high; leaves linear or linear-lanceolate, slender-pointed, narrowed above the spreading and clasping base, spreading or recurved, smooth, with loose, thread-like filaments on the margins; panicle elongated, with bract-like leaves on the scape, widely branched, pubescent above, 3–6 ft. high; perianth white, bell-shaped, 2 in. wide; capsule oblong, angles rounded, sides furrowed, at length 3-valved and dehiscent. May–June. In sandy soil and often cultivated for ornament.

14. CONVALLARIACEÆ. LILY-OF-THE-VALLEY FAMILY.

Perennial herbs, stems leafy or scapose, often from a thickened rootstock, never from a bulb or corm; flowers solitary or variously clustered; leaves broad and often with netted veins, or filiform, alternate or whorled; perianth 4–6-parted, segments distinct or partly united; stamens 4–6, hypogynous or inserted on the perianth; ovary free, 2–3-celled, ovules few or many, style long or short, stigmas mostly 3-lobed; fruit a berry.

I. ASPARAGUS.

Stem from fleshy fibrous roots, erect, branched, branches slender, with filiform branchlets in the axils of scales which take the place of leaves; flowers small, solitary or racemed, perianth 6-parted, segments distinct or slightly united; stamens 6, perigynous, filaments filiform; ovary 3-celled, 6-ovuled, style short, slender, stigmas 3, recurved; fruit a globose berry.

A. OFFICINALIS L. ASPARAGUS. Stem succulent and simple with fleshy scales when young, becoming taller, more woody and widely branched when old; leaves short, filiform; flowers axillary, solitary, or 2 or 3 together on slender, jointed, drooping pedicels, greenish, segments linear; berry red, few-seeded. May–August. Introduced from Europe, common in cultivation, and often escaped.

II. POLYGONATUM.

Rootstock creeping, jointed, scarred; stems simple, erect, scaly below, leafy above; leaves alternate, oval or oblong; flowers on axillary, 1–4-flowered, drooping, jointed peduncles, perianth tubular, 6-cleft; stamens 6, included, inserted about the middle of the tube; anthers sagittate; ovary 3-celled, many-ovuled, style slender, stigmas capitate or 3-lobed; fruit a few-seeded berry.

1. P. BIFLORUM (Walt.) Ell. HAIRY SOLOMON'S SEAL. Stem simple, erect, arched, nearly naked below, 1–2 ft. high; leaves 2-ranked, sessile or clasping, 3–7-nerved, smooth above, pale and pubescent beneath; peduncles short, 1–4- often 2-flowered, perianth greenish, $\frac{1}{2}$ in. long; filaments filiform, roughened; berry dark blue. April–May. Shady banks.

2. P. COMMUTATUM (R. & S.) Dietr. SMOOTH SOLOMON'S SEAL. Stem simple, stout, curving above, 3–8 ft. high; leaves lanceolate to ovate, many-nerved, partly clasping, smooth on both sides; peduncles nearly half as long as the leaves, 2–6-flowered; perianth greenish yellow, $\frac{3}{4}$ in. long; filaments smooth; berry blue, $\frac{1}{2}$ in. in diameter. May–June. In rocky woods and along streams.

III. MEDEOLA.

Rootstock horizontal, fleshy; stem simple, erect; leaves in two whorls; flowers perfect, in a sessile umbel; perianth

greenish-yellow, segments 6, distinct, deciduous; stamens 6, hypogynous, filaments slender, smooth; ovary 3-celled, many-ovuled, styles 3, slender, recurved; fruit a globose berry.

M. Virginiana L. Indian Cucumber-root. Stem clothed with loose deciduous wool, erect, 1–2 ft. high; the lower whorl of 6–8 sessile, oblong-lanceolate, acuminate, 3–5-nerved leaves, the upper whorl of 3–4, ovate, sessile or short-petioled leaves; flowers 2–8, nodding, becoming ascending in fruit; perianth segments $\frac{1}{4}$–$\frac{1}{3}$ in. long, obtuse; styles red, berry dark purple. May–June. Shady banks and moist woods.

IV. TRILLIUM.

Perennial, from tuberous rootstocks; stem simple, erect; leaves 3, whorled at the summit of the stem; flower terminal, solitary, peduncled or sessile, perfect; perianth of 6 leaves, the 3 outer green, persistent, the 3 inner colored and petal-like, deciduous or persistent; stamens 6, hypogynous, filaments short; ovary sessile, 6-ribbed, 3-celled, many-ovuled, styles 3, slender, recurved, persistent; fruit a subglobose, many-seeded purple berry.

1. T. sessile L. Sessile-flowered Wake-robin. Rootstock erect or ascending, corm-like; stem slender, 1–8 in. high; leaves broadly oval, obtuse or acute at the apex, rounded and sessile at the base, 3–5-nerved, smooth, bright green, not mottled; flowers sessile, sepals lanceolate, $\frac{2}{3}$–1 in. long, petals purple, elliptical, about the length of the sepals; stamens half the length of the petals; styles elongated, straight. April–May. In rich woods.

2. T. Underwoodii Small. Underwood's Wake-robin. Rootstock horizontal, stem stout, 4–12 in. high; leaves ovate-lanceolate to broadly ovate, acute or short acuminate at the apex, rounded and sessile at the base, wavy on the margins, 3–5-nerved, glabrous, prominently mottled with different shades of green; flowers sessile, sepals lanceolate, 1$\frac{1}{2}$–2 in. long, often purplish green, petals purple, lanceolate to oblanceolate, 2–3 in. long; stamens $\frac{1}{4}$–$\frac{1}{3}$ the length of the petals, style very short, stigmas recurved; fruit an ovoid berry. April–May. In rich woods.

3. T. grandiflorum (Michx.) Salisb. Large-flowered Wake-robin. Rootstock horizontal, stem slender, 12–18 in. high; leaves rhombic-ovate, acuminate at the apex, rounded and sessile or slightly peduncled at the base, smooth and glaucous, 5–7-nerved,

bright green; peduncle longer than the erect or slightly declined flower, sepals lanceolate-acute, 1–1½ in. long, petals white fading to pink, longer than the sepals; stamens less than half the length of the petals; style short, stigmas recurved, fruit a black globose berry. April–May. In rich woods.

15. SMILACEÆ. SMILAX FAMILY.

Mostly woody climbing vines with prickly stems; leaves alternate, prominently nerved, netted-veined, petioled, stipules replaced by persistent tendrils; flowers diœcious, small, greenish, in axillary umbels; perianth segments 6; stamens 6, distinct; ovary 3-celled, 3–6-ovuled, stigmas 1–3, sessile or nearly so; fruit a 1–6-seeded globose berry.

SMILAX.

Rootstock often large and tuberous; stems usually woody, climbing by tendrils; leaves entire or lobed; petioles sheathing; flowers regular, perianth bell-shaped, the 6 segments equal and deciduous; stamens 6, inserted on the base of the perianth; ovary free, 1–3-celled, 3–6-ovuled, stigmas 1–3; berry 1–6-seeded.

1. S. HERBACEA L. CARRION-FLOWER. Stem herbaceous, erect, simple or branched, not prickly, 1–3 ft. high; leaves few, ovate, acute and mucronate at the apex, somewhat cordate at the base, 5–7-nerved, thin, smooth above, pubescent below, the upper sometimes whorled and the lower bract-like; petioles short; peduncles as long as the leaves, growing from below the petioles; umbel many-flowered, flowers carrion-scented; berry blue-black, 2–4-seeded. April–June. Dry, fertile soil.

2. S. GLAUCA Walt. GLAUCOUS GREENBRIER. Stem terete, slender, with scattered prickles, branches angled, and usually without prickles; leaves ovate or subcordate, pointed at the apex, mostly 5-nerved, smooth, white-glaucous beneath, margins entire; peduncles flattened, 2–3 times as long as the petioles, few-flowered; berry black, 3-seeded. May–June. Margins of swamps.

3. S. BON-NOX L. BRISTLY GREENBRIER. Stem stout, terete or slightly angled, scurfy when young, armed with numerous stout

prickles; branches 4-angled, usually unarmed; leaves deltoid-ovate or often hastate, 5–7-ribbed, smooth on both sides and often discolored, margins usually fringed with fine prickles; peduncles twice as long as the petioles, flattened; umbels many-flowered, pedicels short; berries 8–20 in a cluster, black, 1-seeded. April–June. In swamps and thickets.

4. S. LAURIFOLIA L. LAUREL-LEAVED GREENBRIER. Stem terete, stout, thickly beset with stout, straight prickles; branches 1-angled, mostly unarmed; leaves thick, evergreen, elliptical to narrowly ovate, obtuse at both ends, smooth, 3-nerved; peduncles shorter than the petioles, angled, stout; pedicels shorter than the peduncles; berries black, 1-seeded, ripening the second season. March–August. Margins of streams and swamps.

5. S. WALTERI Pursh. WALTER'S GREENBRIER. Stem low, with few prickles, 2–5 ft. long, branches slightly 4-angled, unarmed; leaves oblong-lanceolate to oval, obtuse or acute at the apex, rounded or cordate at the base, 5-ribbed, smooth; peduncles flattened, about as long as the petioles and pedicels; berry bright red, ripening the first year. March–April. Wet pine barrens.

16. HÆMODORACEÆ. BLOODWORT FAMILY.

Perennial herbs from short rootstocks; stem erect; leaves linear, equitant; flowers in a terminal cyme or panicle, regular or nearly so, the persistent perianth 6-parted, adnate to the ovary; stamens 3; ovary 1–3-celled, few-ovuled, style slender, stigma entire or lobed; fruit a 3-valved capsule.

GYROTHECA.

Stem stout, leafy; juice orange-colored; leaves narrowly linear, equitant; flowers in a dense, terminal, woolly cyme; perianth 6-parted, woolly without, the three inner segments longer, tube adnate to the ovary; stamens opposite the inner segments, longer than the perianth; style filiform, declined, deciduous, capsule globose, 3-angled, many-seeded.

G. CAPITATA (Walt.) Morong. RED-ROOT. Rootstock rather stout, with coarse, red, fibrous roots; stem mostly simple, smooth below, woolly above; leaves linear, crowded and equitant below,

scattered and clasping above; flowers 2-ranked in a compound woolly cyme, pedicels bracted; perianth woolly without, yellow and smooth within; capsule as long as the pedicels, the valves separating from the placentæ, seeds black. June–September. Swamps and wet places.

17. AMARYLLIDACEÆ. AMARYLLIS FAMILY.

Perennial herbs with a bulbous or tuberous root, mostly succulent; leaves narrow; flowers perfect, often showy, perianth 6-parted, the segments united below to form a tube which is partly or wholly adherent to the ovary; stamens 6, opposite the perianth lobes, anthers versatile or introrse; ovary 3-celled, few- or many-ovuled, style single, filiform, entire or lobed; fruit a capsule or rarely fleshy, valvular or indehiscent.

Plants from bulbs.
  Scape 1-flowered . . . . . I. Amaryllis.
  Scape several-flowered.
    Flowers with a membranous crown . II. Hymenocallis.
    Flowers crownless . . . . . III. Crinum.
Plants from rootstocks.
    Flowers in spikes . . . . . IV. Agave.
    Flowers in umbels . . . . . V. Hypoxis.
    Flowers in panicles . . . . VI. Lophiola.

I. AMARYLLIS.

Acaulescent, from a coated bulb; leaves linear, fleshy; scape erect, 1–few-flowered; flowers large, erect, or declined, subtended by a 1–2-leaved spathe; perianth 6-parted, naked in the throat, tube short, segments petal-like, spreading; stamens free, anthers versatile; ovary 3-celled, many-ovuled, style elongated, declined, stigma 3-cleft; fruit a many-seeded, 3-valved capsule, seeds black, compressed, or angled.

A. Atamasco L. Atamasco Lily. Bulbs about 1 in. in diameter; leaves narrow, concave above, glabrous, usually longer than the scape; scape 6–12 in. high, 1-flowered; spathe 1-leaved, 2 cleft; flowers 2–3

in. long, white tinged with pink or purple, bell-shaped, short-peduncled; stamens longer than the tube, shorter than the style, capsule depressed-globose, seeds angled. April. In rich, damp soil, often cultivated.

II. HYMENOCALLIS.

Acaulescent from a large coated bulb; leaves strap-shaped, long; scape erect, compressed, 2-edged, bearing a cluster of leafy-bracted flowers at the apex; perianth corolla-like, 6-parted, tube long and slender, perianth lobes narrow, spreading, or recurved; stamens 6, the filaments broadened and united below to form a crown with toothed and spreading edge, upper part of the stamens exserted, anthers versatile; style long and slender, stigma entire; fruit a membranaceous, 3-celled capsule, seeds often bulb-like.

H. OCCIDENTALIS (Le C.) Kunth. SWAMP LILY. Bulb 2–3 in. in diameter; leaves linear or strap-shaped, obtuse, thick, glaucous, concave above, 1–2 ft. long; scape stout, 2-edged, as long as the leaves, smooth, about 6-flowered; bracts several, linear-lanceolate; perianth white, the tube slender, 3–5 in. long, not dilated at the apex, perianth lobes linear, spreading or recurved, nearly as long as the tube; crown funnel form, toothed between the filaments, style much exserted, capsule few-seeded. June–August. In wet places.

III. CRINUM.

Characters the same as those of Hymenocallis, excepting that the flowers are crownless.

C. AMERICANUM L. CRINUM. Bulb 2–4 in. in diameter; leaves strap-shaped, obtuse, concave above, slightly denticulate; scape few-flowered, compressed, edges rounded, smooth, 18–24 in. high; bracts lanceolate; flowers 6–8 in. long, white, fragrant, tube green, persistent, perianth segments lanceolate, spreading or recurved, shorter than the tube; stamens exserted, filaments purple; ovary 3-celled, 3–6 ovuled, style slender, purple, stigma truncate, capsule indehiscent, 1–6-seeded, seeds large, corm-like. May–September. River banks and swamps.

IV. AGAVE.

Rootstocks short and thick, tuberous; leaves mostly basal, fleshy, with a toothed or spiny margin; scape tall, with leaf-

like bracts; flowers in simple or panicled spikes, perfect, bracted; perianth tubular-funnel form, 6-lobed, persistent; stamens 6, inserted at the base of the perianth, exserted, anthers versatile; ovary 3-celled, 3-lobed, many-ovuled, style filiform, exserted, stigma 3-lobed, fruit a 3-celled, 3-valved, many-seeded, dehiscent capsule, seeds compressed.

A. Virginica L. False Aloe. Whole plant smooth and glaucous; leaves lanceolate, thick, long, acuminate and spine-pointed, sparingly denticulate, surface often mottled; scape erect, simple, very white-glaucous, 3–5 ft. high; spike simple, flowers greenish-yellow, perianth tubular, strongly nerved, about 1 in. long, lobes short, slightly spreading; filaments and style spotted, capsule coriaceous, 3-lobed at the apex, seeds shiny. June–August. In dry soil.

A. Americana L., the century plant, is often cultivated for ornament in the southern section.

V. HYPOXIS.

Low herbs; rootstock short, tuberous; leaves grass-like; scape naked, bearing a few yellow flowers in a bracted umbel, perianth 6-parted, spreading, persistent, the outer segments green on the outside, tube short; stamens 6, inserted at the top of the tube, short, unequal; ovary 3-celled, many-ovuled, style short and thick, stigmas 3, fruit a top-shaped, many-seeded capsule, the upper portion with the withered perianth falling off at maturity, seeds globose, black, beaked by their persistent stalks.

H. hirsuta (L.) Coville. Star-grass. Leaves linear, grass-like, channeled above, hirsute or woolly, becoming longer than the scape; scapes 1–4, slender, somewhat flattened, usually smooth below and hairy above, 3–6 in. high; bracts subulate, shorter than the unequal, hairy pedicels; perianth segments oblong, obtuse, yellow within, green and hairy without, stamens unequal, longer than the style; capsule several-seeded, seeds angled. March–July. Common on low ground.

VI. LOPHIOLA.

Perennial herbs from slender rootstocks; stem leafy; leaves linear and rigid; inflorescence in a terminal, woolly, cymose panicle; flowers small, yellow, woolly without, perianth 6-

lobed, the tube adherent to the lower part of the ovary, lobes spreading; stamens 6, inserted on the lower part of the perianth lobes, filaments slender, short; ovary 3-celled, many-ovuled, style slender, erect, persistent, shorter than the stamens; fruit a 3-ribbed, 3-furrowed capsule; seeds oblong, ribbed.

L. AMERICANA (Pursh) Coville. LOPHIOLA. Stem erect, rigid, smooth below, branched and woolly above; basal leaves linear, sword-shaped, equitant, upper leaves scattered, smaller; panicle very white-woolly, becoming broad in fruit; perianth segments linear-oblong, with a tuft of wool at the base within; capsule shorter than the perianth, ovoid. June–August. Wet pine barrens.

18. IRIDACEÆ. IRIS FAMILY.

Perennial herbs from bulbs or rootstocks; leaves 2-ranked, equitant; flowers perfect, regular or irregular, each subtended by two bracts; perianth 6-parted, the tube adherent to the ovary, the segments in 2 series of 3 each, equal, or the inner ones smaller; stamens 3, distinct or united, opposite the outer segments; ovary forming a 3-celled, 3-angled, 3-valved, many-seeded, dehiscent capsule.

I. IRIS.

Rootstock thick, creeping, branching, horizontal, sometimes tuberous; stems erect, simple or branched; leaves linear or sword-shaped; flowers showy, the outer perianth segments spreading or recurved, often bearded within, the inner segments usually smaller and erect; stamens inserted in the base of the outer segments; the style deeply 3-parted, the divisions broad and petal-like, covering the stamens; fruit an oblong or oval, 3 or 6-angled, many-seeded capsule.

1. I. VERSICOLOR L. LARGE BLUE FLAG. Rootstock thick, horizontal; stem terete, smooth, simple or branched, leafy, 2–3 ft. high; leaves linear-sword-shaped, finely-nerved, glaucous, the lower 1½–2 ft. long, the upper shorter; bracts longer than the pedicels; flowers terminal, single or few together, blue variegated with white, yellow, and purple, perianth segments not bearded, the inner ones smaller;

the 3-angled ovary longer than the inflated perianth tube, capsule oblong, slightly lobed, seeds in 2 rows in each cell. April–May. In wet places.

2. I. HEXAGONA Walt. SOUTHERN BLUE FLAG. Rootstock thick; stem terete, erect, usually simple, 2–3 ft. high; leaves linear, sword-shaped, as long as the stem, green; flowers axillary and terminal, deep blue, variegated with white, yellow, and purple, outer segments not bearded, often 4 in. long, inner segments smaller; perianth tube longer than the ovary; stigmas much longer than the stamens, cut-toothed at the apex, capsule oblong-cylindrical, 6-angled. April–May. In wet ground.

3. I. GERMANICA L. FLEUR-DE-LIS. Rootstock thick, matted; stem stout, branched, leafy, 2–3 ft. high; leaves strap-shaped, acute, erect, shorter than the stem, bracts scarious; flowers sessile, large and showy, blue, variegated with white and yellow, sometimes nearly all white, outer segments large, recurved, bearded, the inner narrower, erect, or arched inward. April–May. Introduced from Europe; common in gardens and naturalized in many places.

4. I. FULVA Ker. YELLOW FLAG. Rootstock fleshy; stem simple or branched, striate, 1-angled below, bearing 2–3 leaves, 2–3 ft. high; leaves linear, sword-shaped, glaucous, shorter than the stem, bracts small; pedicels short, flowers axillary and terminal, dull yellow or reddish-brown, variegated with blue and green, perianth segments not bearded; style branches but little exceeding the stamens, ovary about as long as the inflated perianth tube, capsule ovate, 6-angled. April–May. Swamps and wet places.

II. SISYRINCHIUM.

Perennial, tufted herbs; stems erect, simple, or branched, flattened, 2-edged or winged; leaves linear and grass-like; flowers small, blue, in terminal, umbellate, 2-bracted clusters, perianth corolla-like, tube short or none, segments 6, equal, strongly aristate; stamens 3, monadelphous; ovary 3-celled, many-ovuled, style short, the branches long, filiform, and involute, alternate with the stamens; fruit a 3-valved capsule, seeds smooth or pitted.

1. S. GRAMINOIDES Bickn. BLUE-EYED GRASS. Stem slender, broadly wing-margined, usually 2-branched above, 10–20 in. high; leaves very slender and grass-like, shorter than the stem, the edges roughened; bracts about 1 in. long, the outer one sometimes the longer; umbels 2–4-flowered, pedicels slender, longer than the bracts,

flowers bright blue, segments cuneate, slightly pubescent without; capsule globose, seeds black, pitted. April–June. Grassy meadows and dry soil.

2. S. ATLANTICUM Bickn. EASTERN BLUE-EYED GRASS. Tufted, stems slender, sharply 2-edged, weak and often decumbent, finally few-branched, 6–18 in. high; leaves pale, glaucous, much shorter than the stem; bracts nearly equal, often somewhat scarious and purple-tinged; flowers bright blue, perianth minutely pubescent without, pedicels erect, about as long as the bracts; capsule ovoid, seeds ovoid, dull black, smooth or minutely pitted. April–June. On moist, sandy soil.

19. ORCHIDACEÆ. ORCHIS FAMILY.

Perennial herbs, roots bulbous, tuberous, corm-like, or fibrous; stems simple, leafy, or scapose; leaves simple, mostly alternate, sheathing, entire, smooth, or rarely pubescent, those on the stem often small and bract-like; flowers solitary, spiked or racemed, usually showy, perfect, very irregular; perianth 6-parted, segments united below and coherent with the ovary, the 3 outer divisions sepal-like and similar; two of the inner segments similar, the third, which is structurally the posterior segment, though often becoming anterior by the twisting of the ovary, very variable in form, sometimes forming a large pouch, often dilated and fringed, and usually forming a knob, or even a long and slender spur near the base; stamens 3, rarely 2, united with the style to form an irregular column, only one or two of them anther-bearing; anthers 2-celled, pollen grains cohering in 2–8 waxy or powdery masses (pollinia) attached to a viscid gland at the base; ovary usually elongated, 1-celled, with 3-parietal placentæ; fruit a 3-valved, many-seeded, dehiscent capsule, seeds minute, covered with a loose, membranous coat.

[Most of the species flower late in the season, and their classification is based principally on the number and character of the anthers and pollinia.]

SUBCLASS 2. DICOTYLEDONS.

Stems with distinct bark, wood, and pith; fibrovascular bundles in rings; leaves netted-veined; parts of the flower mostly in 5's, rarely in 3's or 6's; cotyledons 2.

20. **SAURURACEÆ.** LIZARD-TAIL FAMILY.

Perennial herbs; stems jointed; leaves simple, alternate, entire, with sheathing stipules; flowers perfect, in bracted, terminal spikes or racemes; perianth none, stamens 4–8, hypogynous; ovaries 3–5, more or less united, ovules few; styles 3–5; fruit a few-seeded capsule, or somewhat fleshy.

SAURURUS.

Characters of the family.

S. CERNUUS L. LIZARD-TAIL. Stem erect, from a slender rootstock, forked above, pubescent when young, becoming smooth, 2–4 ft. high; leaves cordate to ovate, strongly 5–9-ribbed, acute or acuminate at the apex, on stout petioles; spikes slender, drooping at the apex, closely flowered, peduncled; flowers white, fragrant, bracted; stamens spreading, filaments club-shaped; fruit somewhat fleshy, of 3–4 carpels, each carpel 1–2-seeded. May–August. In marshes and muddy places.

21. **JUGLANDACEÆ.** WALNUT FAMILY.

Trees with alternate, odd-pinnate leaves without stipules; flowers monœcious, the staminate in long and drooping aments, stamens few or many, calyx 2–6-parted; the fertile solitary or in small clusters, calyx 3–5-lobed, minute petals sometimes present, ovary 1-celled or incompletely 2–4-celled; fruit a drupe with a dry exocarp enclosing a bony endocarp or nut.

I. JUGLANS.

Staminate aments cylindrical, solitary, borne on wood of the previous year, stamens numerous, filaments short, calyx 4–6-parted; pistillate flowers single or a few together on a short peduncle at the base of the growth of the season; calyx 4-parted, petals 4, minute, adnate to the ovary; styles 2, short, plumose, fruit large, globose or oval, exocarp fibrous-fleshy, becoming dry, indehiscent, endocarp bony, very rough.

1. J. NIGRA L. BLACK WALNUT. Leaflets 13–21, ovate-lanceolate, serrate, acuminate, somewhat cordate or oblique at the base, nearly smooth above, pubescent beneath, petioles minutely downy; fruit usually single, globose, about 2 in. in diameter. April–May. On rich soil, rare near the coast. One of the most valuable of our native trees, the wood being very durable and highly prized for cabinet work.

2. J. CINEREA L. BUTTERNUT. Leaflets 15–19, ovate-lanceolate, acuminate at the apex, rounded or slightly inequilateral at the base, serrate, downy beneath; petioles, branchlets, and fruit viscid-pubescent; fruit often in small clusters, oblong. April–May. More common northward. Wood less valuable and nut less oily than Black Walnut. The English Walnut (*J. regia*) is occasionally seen in cultivation. It has 7–11 leaflets and a nearly smooth endocarp.

II. HICORIA.

Leaflets serrate; staminate aments usually in 3's on a common peduncle, or sometimes sessile at the base of the growth of the season; calyx 2–3-parted, stamens 3–10, filaments short; pistillate flowers 2–5 in terminal clusters, calyx 4-parted, petals none, styles 2 or 4, fimbriate; fruit subglobose, exocarp separating more or less completely into 4 valves, endocarp smooth or angled.

1. H. PECAN (Marsh) Britt. PECAN. A large tree with rough gray bark, young twigs and leaves pubescent, nearly glabrous when mature; leaflets 11–15, oblong-lanceolate, acuminate, serrate, falcate; staminate aments nearly sessile, 5–6 in. long; exocarp thin, nut oval or oblong, thin-shelled. March–April. River-bottoms. Rarely native east of the Mississippi River, but widely planted for its fruit.

2. H. ovata (Mill) Britt. Scaly-bark Hickory. A large tree with bark scaling off in long plates, young twigs and leaves downy, becoming smooth with age; leaflets 5, the lower ones oblong-lanceolate, the upper one longer and obovate, acuminate at the apex, narrowed to the sessile base; inner bud scales becoming large and conspicuous; staminate aments in 3's; fruit globose, exocarp thick, splitting into 4 sections, nut white, compressed, 4-angled, pointed, thin-shelled. March–April. On rich soil. More common in the northern section. Wood strong and elastic, but not durable when exposed.

3. H. glabra (Mill) Britt. Pig-nut Hickory. A large tree with close, rough bark; young twigs and leaves nearly glabrous; leaflets 5–7, usually 7, ovate-lanceolate, acuminate, sessile, 3–6 in. long; staminate aments in 3's; fruit oval to pear-shaped, exocarp thin, splitting to about the middle; nut brown, angled, thick-shelled, kernel at first sweet, the after-taste bitter. March–April. Common on rich soil. Wood very strong and elastic. Used largely for handles of tools. Six other species of hickory are more or less common throughout the South.

22. MYRICACEÆ. BAY-BERRY FAMILY.

Shrubs with alternate, simple, resinous-dotted leaves; monœcious or diœcious; flowers in short, bracted aments, perianth none; staminate flowers 2–10, stamens inserted on the receptacle; pistillate flowers surrounded by 2–6 scales, ovary 1-celled, style short, stigmas 2.

MYRICA.

Shrubs or small trees with the branches clustered at the end of the growth of the previous season; leaves short-petioled, entire, lobed or dentate, the margin usually revolute, without stipules; perianth none; staminate flowers in oblong or cylindrical aments, stamens 2–10, with the filaments united below; pistillate flowers surrounded by a cup of 2–6 scales, ovary solitary, becoming a 1-celled, globose drupe or nut, often covered with waxy grains. Whole plant usually fragrant.

M. cerifera L. Waxberry. A spreading shrub or small tree; young branches pubescent; leaves lanceolate or oblong-lanceolate,

entire or sometimes serrate near the mostly obtuse apex, smooth or pubescent on the veins beneath, tapering into a short petiole; staminate aments numerous, stamens 4; pistillate aments small, bracts slightly 3-lobed, scales of the ovary 4, ciliate; stigmas 2, fruit very abundant, incrusted with white wax, $\frac{1}{8}$–$\frac{1}{6}$ in. in diameter, sometimes persistent 2 or 3 years. March–April. Common on wet soils, especially near the coast.

23. SALICACEÆ. WILLOW FAMILY.

Trees or shrubs with simple, alternate, deciduous, stipulate leaves, buds scaly, covered with a resinous varnish; flowers diœcious, in aments expanding before or with the leaves; staminate aments usually drooping, flowers consisting of one or more stamens inserted on a receptacle in the axil of a simple bract; pistillate aments drooping, erect, or spreading; ovary 1-celled, with 2–4 placentæ and usually numerous ovules, style short, stigmas 2, often 2-lobed; seeds small, covered with fine silky hairs.

I. POPULUS.

Trees with prominent, scaly buds, twigs more or less angled, leaves usually long-petioled, bracts of the aments irregularly lobed at the apex; stamens few or many, filaments distinct; pistillate aments often long, ovary sessile, style short, stigmas 2–4, elongated, capsule 2–4-valved.

1. P. DELTOIDES Marsh. COTTONWOOD. Branches acutely angled; leaves glabrous, large, deltoid, acute or acuminate at the apex, truncate at the base, obtusely serrate, petioles flattened laterally; pistillate aments 6–10 in. long at maturity, capsule usually shorter than the pedicel. March–May. On damp soil.

2. P. HETEROPHYLLA L. SWAMP POPLAR. Branches only slightly angled; leaves ovate, mostly obtuse at the apex, rounded or sub-cordate at the base, serrate with obtuse teeth, densely tomentose when young, but becoming smooth with age; petioles terete; pistillate aments smooth, erect or spreading, loosely flowered; capsule ovoid, usually shorter than the pedicel. March–April. Common in river swamps. A large tree with soft, light wood, which is often used in making cheap furniture.

II. SALIX.

Shrubs or trees, branches usually very slender, buds with single scales; leaves usually long and narrow; stipules sometimes leaf-like or often small and soon deciduous; bracts of the aments entire; staminate aments erect or drooping, staminate flowers with 2–10, mostly 2, distinct or united stamens; pistillate aments usually erect, flowers with a small gland on the inner side of the bract, stigmas short, 2-lobed; capsule 2-valved.

1. S. NIGRA Marsh. BLACK WILLOW. Leaves elliptical or narrowly lanceolate, acute at each end, serrate, short-petioled, downy when young and becoming smooth with age, 2–3 in. long; stipules persistent or deciduous; staminate aments 1–2 in. long; the pistillate 2–4 in. long; stamens 3–7, distinct, filaments pubescent below; capsule twice the length of the pedicel, ovate, acuminate, pointed by the prominent style. March–April. A small tree with very brittle branches. Along streams and borders of marshes.

2. S. BABYLONICA L. WEEPING WILLOW. Leaves narrowly lanceolate, acuminate, serrate, slightly downy when young and becoming smooth with age, green above, pale beneath, often 5–7 in. long, petioles short, glandular; aments on short lateral branches; stamens 2, style almost none, capsule sessile, glabrous. March–April. Introduced and cultivated for ornament, becoming a large tree.

24. BETULACEÆ. BIRCH FAMILY.

Trees or shrubs, with alternate, simple, petioled leaves with usually deciduous stipules; monœcious flowers in cylindrical or subglobose aments, staminate aments drooping; flowers 1–3 in the axil of each bract, calyx none, or membranous and 2–4-parted; stamens 2–10, distinct; pistillate aments drooping, spreading, or erect and spike-like; flowers with or without a calyx, ovary solitary, 1–2-celled, ovules 1–2 in each cell; fruit a 1-celled nut or samara.

I. CARPINUS.

Trees with thin, straight-veined leaves, which are folded in the bud; flowers expanding before the leaves; staminate

flowers in slender, drooping aments sessile at the end of the growth of the previous season; stamens 3–12, subtended by a bract, filaments forked, anthers hairy; pistillate aments spike-like, each pair of flowers subtended by a deciduous bract, and each flower by a persistent bractlet which becomes large and leaf-like in fruit; ovary 2-celled, 2-ovuled; stigmas 2, filiform; fruit a small angular nut.

C. Caroliniana Walt. Hornbeam. A small tree with smooth and close gray bark; twigs slender; leaves ovate-oblong, acute or acuminate, sharply and doubly serrate, the straight veins terminating in the larger serrations; downy when young and soon becoming smooth; staminate aments 1–1½ in. long; pistillate aments long-peduncled, 8–12-flowered; bractlets becoming nearly 1 in. long, cut-toothed, the middle tooth much longer than the others. February–March. In rich, moist woods. Often known as "blue beech" and "iron wood."

II. OSTRYA.

Small trees, with dark bark and very hard wood; leaves open and concave in the bud and somewhat plaited on the veins; staminate flowers on slender, drooping aments sessile at the end of the growth of the previous season; stamens 3–12, subtended by a bract, filaments forked, anthers hairy; pistillate flowers surrounded by a tubular bractlet which becomes large and bladder-like at maturity; fruit a small, pointed, smooth nut; mature ament hop-like.

O. Virginiana (Mill) Willd. A small tree with brownish, furrowed bark; leaves ovate, acute, doubly serrate, often inequilateral at the base, short-petioled; staminate and fertile aments 2–3 in. long. February–March. Mature fruit June–July. In rich woods. Often known as "iron wood" and "lever wood."

III. CORYLUS.

Shrubs with prominently veined, cut-toothed leaves which are folded lengthwise in the bud, and with the flowers expanding before the leaves; staminate flowers in slender, drooping aments; stamens 8, anthers 1-celled; fertile flowers several in a cluster or in very short aments at the ends of the twigs of the season; ovary incompletely 2-celled, style short, stig-

mas 2, bractlets 2, becoming enlarged and enclosing the single bony nut at maturity.

C. Americana Walt. Hazel-nut. A shrub 4–7 ft. high, young twigs and petioles covered with brownish, viscid hairs; leaves round-cordate, acute or acuminate, irregularly toothed, nearly smooth above, pubescent below; involucre longer than the nut and enclosing it, glandular-hairy; nut subglobose, pointed, edible. February–March. On rich soil, borders of meadows and fields.

IV. BETULA.

Trees with slender, aromatic twigs and thin, usually straight-veined leaves; staminate aments drooping, flowers usually 3 in the axil of each bract, stamens 4, short, anthers 1-celled; pistillate aments erect, flowers 2 or 3 in the axil of each bract; ovary sessile, 2-celled, styles 2; bracts 3-lobed; perianth none; nut broadly winged.

1. B. nigra L. Black Birch. A medium-sized tree with reddish-brown bark; leaves rhombic-ovate, acute at the apex, acute or obtuse at the base, sharply and doubly serrate, white-downy below, becoming smoother with age, petioles short; staminate aments 2–3 in. long; pistillate aments 1–1½ in. long, peduncles short, bracts nearly equally 3-cleft, woolly. March–April. River banks.

2. B. lenta L. Cherry Birch. Leaves ovate or oblong-ovate, acute, cordate, finely and doubly serrate, silky when young; petioles about ½ in. long; staminate aments clustered, 3–4 in. long; pistillate aments sessile, about 1 in. long, cylindrical bracts spreading, acute, smooth. March–April. River banks, especially in the northern districts. A large tree with aromatic twigs. The oil contained in the bark and twigs is distilled and used as a substitute for wintergreen.

V. ALNUS.

Shrubs or small trees; leaves petioled, serrate; flower buds stalked, appearing the previous season; staminate aments racemed, drooping flowers 3–6 in the axil of each bract, subtended by 1–2 bractlets, perianth 4-parted, stamens 4, filaments short; pistillate aments erect, flowers 2–3 in the axil of each bract, perianth replaced by 2–4 minute bractlets which are adherent to the bract; ovary 2-celled, styles 2, fruit a

winged or angled nut; bracts of the pistillate flowers somewhat fleshy, persistent, becoming woody in fruit.

A. RUGOSA (Du Roi) Koch. SMOOTH ALDER. A shrub or small tree with smooth bark; leaves obovate, rounded or obtuse at the apex, acute at the base, sharply and minutely serrate, glabrous above, pubescent beneath, petioled, stipules oval, deciduous; staminate aments 2–4 in. long; fruiting aments ovoid, short-peduncled, fruit ovate, wingless. January–March. Banks of streams and borders of marshes. Leaves often persistent during the winter.

25. FAGACEÆ. BEECH FAMILY.

Trees or shrubs; leaves alternate, simple, pinnately veined; stipules deciduous; flowers monœcious, the staminate capitate, or in drooping, spreading, or erect aments, calyx minute, petals none, stamens 4–20; pistillate flowers solitary or in small clusters, each flower subtended by more or less united bracts which at maturity form a cup or burr, calyx minutely toothed, petals none; ovary 2–7 celled, but becoming 1-celled; fruit a 1-seeded nut.

I. FAGUS.

Trees with smooth, close, ash-gray bark, and slender, often horizontal branches; staminate flowers in long, slender-peduncled, globose clusters, calyx bell-shaped, 4–6-cleft, stamens 8–12, anthers 2-celled; pistillate flowers solitary or more often in pairs, peduncled, surrounded by a 4-lobed involucre and numerous linear bracts; ovaries 3-celled with 2 ovules in each cell, but usually only one ovule matures in each ovary; styles 3, filiform, fruit a thin-shelled, 3-angled nut.

F. AMERICANA Sweet. BEECH. Large trees, leaves oblong-ovate, acuminate at the apex, serrate, straight-veined, very white-silky when young, nearly glabrous with age, involucre densely covered with short recurved spines; nuts thin-shelled, edible. March–April. Common on damp soil everywhere. The wood is very hard, tough, and close-grained, and is especially valuable for the manufacture of small tools.

II. CASTANEA.

Trees or shrubs with rough, gray, rather close bark; leaves straight-veined, undivided, prominently toothed; flowers appearing later than the leaves; staminate aments erect or spreading, loosely flowered, flowers several in the axil of each bract, calyx 4–6-parted, stamens 8–16; pistillate flowers at the base of the staminate ament or in small separate clusters, usually 3 in each involucre; ovary 4-celled, surrounded by 5–12 abortive stamens, fruit a 1-celled nut enclosed in the greatly enlarged and very prickly involucre.

1. C. DENTATA (Marsh) Berkh. AMERICAN CHESTNUT. A large tree, bark somewhat rough, and splitting into longitudinal plates; leaves oblong-lanceolate, acuminate at the apex, usually acute at the base, coarsely and sharply serrate with ascending teeth, glabrous, dark green above, lighter below; petioles stout, short; staminate aments erect, 6–10 in. long; nuts usually 3 in each burr. February–March. Rich soil in the upper districts. Rarely found on soils containing much lime.

2. C. PUMILA (L.) Willd. CHINQUAPIN. A small tree or shrub; leaves oblong, acute or obtuse at both ends, serrate with divergent teeth, dark green and smooth above, white-woolly below; nuts solitary, nearly globular. March–April. Common southward in rich woods.

III. QUERCUS.

Trees or shrubs, with entire, serrate or lobed leaves which are often persistent; staminate flowers in slender aments, each subtended by quickly deciduous bracts, and consisting of 3–12 stamens enclosed by a 4–8-parted perianth, often containing an abortive ovary; pistillate flowers solitary or in small clusters, each consisting of a 3-celled ovary with 2 ovules in each cell, though rarely more than 1 ovule matures; styles short, erect or recurved; pistillate flowers surrounded by a scaly involucre which at maturity becomes a cup enclosing the base of the fruit or sometimes a large part of it; fruit an ovate or subglobose, 1-seeded, thin-shelled nut (acorn).

A. Fruit biennial; leaves entire or with bristle-pointed lobes.

1. Q. RUBRA L. RED OAK. A large tree; leaves oval or obovate, green above, pale and slightly pubescent beneath, sinuses shallow and rounded, lobes 8–12, acuminate; petioles long; cup saucer-shaped, with fine scales; acorn ovate or oblong, about 1 in. long. April–May. Common; wood not valuable; leaves turning red after frost and often remaining on the tree through the winter.

2. Q. VELUTINA Lam. BLACK OAK. A large tree with rough, dark brown outer bark and thick, bright yellow inner bark; leaves broadly oval, usually divided more than halfway to the mid-rib, sinuses rounded; lobes about 7, sharply toothed at the apex, smooth above, usually pubescent on the veins beneath; cup hemispherical or top-shaped, with coarse scales, short-peduncled, enclosing about half the roundish acorn. April–May. Common; wood not valuable, but the inner bark used for tanning and dyeing.

3. Q. DIGITATA (Marsh) Sudw. SPANISH OAK. A small or medium-sized tree with leaves 3–5-lobed at the apex, obtuse or rounded at the base, grayish downy beneath, lobes lanceolate and often falcate, sparingly cut-toothed; cup top-shaped, with coarse scales, enclosing about half the nearly globose acorn. April–May. Common in dry woods. Foliage quite variable in outline and lobing; bark valuable for tanning.

4. Q. NIGRA L. BLACK-JACK OAK. A small tree; leaves obovate, usually with three rounded lobes at the apex, the lobes bristle-pointed, rounded, or slightly cordate at the base, rusty-pubescent beneath, shining above, coriaceous, short-petioled; cup top-shaped, short-peduncled, with coarse and truncate scales, enclosing about one-third of the oblong-ovate acorn. April–May. An almost worthless tree, its presence indicating a thin and sterile soil.

5. Q. PHELLOS L. WILLOW OAK. A tree of medium size, leaves lanceolate or elliptical, scurfy when young and becoming smooth with age; very short-petioled; cup shallow, sessile; acorn subglobose. March–April. Wet soil; often planted for shade.

B. Fruit annual; leaves not bristle tipped, though often mucronate.

6. Q. ALBA L. WHITE OAK. A large tree with light gray bark; leaves obovate-oblong, 3–9-lobed, lobes rounded and mostly entire, bright green above, paler below, short-petioled; cup hemispherical, scales rough, woolly when young, but becoming glabrous with age; acorn oblong-ovate, about 1 in. long. March–April. Common in damp soil; wood strong and durable; one of the most valuable timber trees.

7. Q. MINOR (Marsh) Sarg. POST OAK. A tree of medium size, with rough, gray bark; leaves broadly obovate, deeply lyrate-pinnatifid into 5–7 rounded, divergent lobes, upper lobes much the longer, smooth above, tomentose beneath, petioles about 1 in. long; cup hemispherical, nearly sessile; acorn ovoid, 2–3 times as long as the cup. March–April. On dry soil; wood hard and valuable.

8. Q. LYRATA Walt. SWAMP OAK. A large tree with gray or reddish bark, leaves obovate-oblong, deeply pinnatifid, lobes narrow, often toothed, thin, glabrous above, white tomentose beneath; cup round-ovate, scales cuspidate, enclosing nearly the whole of the depressed-globose acorn. March–April. On wet soil; wood strong and very durable.

9. Q. PRINUS L. SWAMP CHESTNUT OAK. A large tree, with brown, ridged bark; leaves oblong or oblong-lanceolate, rather obtuse, crenately toothed, minutely downy beneath, petioles slender, about 1 in. long; cup hemispherical, peduncles longer than the petioles, scales acute, tubercular, appressed; acorn oblong, acute, 1 in. or less in length, edible. March–April. Common on low ground. Wood strong and valuable.

10. Q. ACUMINATA (Michx.) Sarg. YELLOW CHESTNUT OAK. A tree of medium or large size with gray bark, leaves oblong or oblanceolate, usually acute at the apex and obtuse or rounded at the base, coarsely and evenly toothed; veins straight, impressed above and prominent beneath; petioles slender; cup hemispherical, sessile or short-peduncled, with flat scales, $\frac{1}{2}$ in. broad, enclosing about half the ovoid acorn which is $\frac{2}{3}$–$\frac{3}{4}$ in. long. March–April. Common on dry soil; wood close-grained, durable, and valuable.

11. Q. VIRGINIANA Mill. LIVE OAK. A large tree with rough gray or brown bark and a low spreading head; leaves coriaceous, evergreen, oblong or oblanceolate, often somewhat 3-lobed on young trees, margin revolute, dark green and shining above, pale below; petioles short, stout; fruit often in short racemes, cup top-shaped, scales closely appressed, hoary, peduncles $\frac{1}{2}$–1 in. long; acorn from subglobose to oblong, the longer form occurring on the younger trees. March–April. On low ground near the coast; wood very hard and durable; valued for ship-building.

26. ULMACEÆ. ELM FAMILY.

Trees or shrubs with watery juice, alternate, simple, petiolate, serrate, stipulate leaves which are usually 2-ranked; and small, perfect or polygamous, apetalous flowers; calyx of 3–9

sepals which are distinct or partly united, stamens as many as the sepals and opposite them; ovary 1–2-celled, styles 2, spreading; fruit a samara, nut, or drupe.

I. ULMUS.

Trees with straight-veined, inequilateral, doubly serrate leaves; stipules early deciduous; flowers perfect, calyx bell-shaped, 4–9-cleft, stamens slender, exserted; ovary compressed, styles 2, spreading, fruit membranaceous, flat, winged on the edge.

1. U. Americana L. White Elm. A large tree with gray bark and smooth or slightly pubescent twigs; leaves oval or obovate, abruptly acuminate at the apex, obtuse and oblique at the base, slightly rough above, soft pubescent or soon glabrous beneath; flowers in close fascicles, peduncles slender, smooth; fruit oval or obovate, with 2 sharp, connivent teeth at the apex, wing reticulate-veined, downy on the margin. Flowers February–March; fruit ripe April–May. In moist, rich soil. A widely planted ornamental tree; wood strong but warping badly, and not durable when exposed.

2. U. alata Michx. Winged Elm. A small tree with branches corky-winged, leaves small, ovate-lanceolate, acute, sharply serrate, base nearly equal-sided, rough above, pubescent beneath, nearly sessile; flowers in small clusters, fruit oblong, downy on the sides, ciliate on the edges. Flowers February–March; fruit April–May. On rich soil. Occasionally producing a second set of flowers and fruit from September to November.

3. U. fulva Michx. Slippery Elm. A tree of medium size with rough pubescent twigs, and rusty-tomentose bud scales; leaves large, thick, very rough above, pubescent beneath, ovate or obovate, acuminate at the apex, inequilateral, obtuse or somewhat cordate at the base, coarsely and doubly serrate, calyx lobes and pedicels pubescent; fruit broadly oval, pubescent over the seed, the wing smooth. February–March. Inner bark very fragrant when dried, and a popular domestic remedy.

II. CELTIS.

Trees or shrubs, with entire or serrate, petiolate leaves; flowers greenish, axillary, on wood of the same season, the staminate in small clusters, the fertile single or 2–3 together.

1. C. OCCIDENTALIS L. HACKBERRY. A large or medium-sized tree having much the appearance of an elm, bark dark and rough; leaves ovate, acuminate at the apex, abruptly obtuse and inequilateral at the base, sharply serrate, often 3-nerved from the base, glabrous above, usually somewhat pubescent below; fruit a small, dark purple drupe. March–April. On rich soil.

2. C. MISSISSIPPIENSIS Bosc. SOUTHERN HACKBERRY. A tree, usually smaller than the preceding, bark gray, often very warty; leaves broadly lanceolate or ovate, long-acuminate at the apex, obtuse or sometimes cordate at the base, entire or with very few serratures, glabrous on both sides, 3-nerved; fruit a purplish-black, globose drupe. March–April.

27. MORACEÆ. MULBERRY FAMILY.

Trees, shrubs, or herbs, usually with milky juice, alternate leaves, large deciduous stipules and small monœcious or diœcious flowers crowded in spikes or heads or enclosed in a fleshy receptacle; staminate flowers with a 3–4-lobed calyx, stamens 3–4, inserted on the base of the calyx, filaments usually inflexed in the bud, straightening at maturity; pistillate flowers 3–5-sepalous; ovary 1–2-celled, 1–2-ovuled; styles 2, receptacle and perianth often fleshy at maturity.

I. MORUS.

Trees or shrubs with milky juice, rounded leaves, and monœcious flowers in axillary spikes; staminate flowers with a 4-parted perianth, and 4 stamens inflexed in the bud; pistillate flowers with a 4-parted perianth which becomes fleshy in fruit, ovary sessile, stigmas 2, linear, spreading; the fleshy perianth enclosing the ovary at maturity.

1. M. RUBRA L. RED MULBERRY. A small tree; leaves cordate-ovate, often 3–5-lobed on vigorous shoots, acuminate at the apex, serrate, rough above, white tomentose beneath; mature fruiting spikes oblong, drooping, dark red or purple, edible. On rich soil. Flowers March–April; fruit May–June. Wood very durable, bearing exposure to the weather.

2. M. ALBA L. WHITE MULBERRY. A small tree; leaves ovate-cordate, acute at the apex, rounded and often oblique at the base, serrate or sometimes lobed, smooth and shining on both sides, mature fruit light red or white. April–May. Fruit June–July. Introduced and common about old dwellings.

II. TOXYLON.

A small tree with milky juice; leaves alternate, petioled, spines axillary; flowers diœcious; staminate flowers in short axillary racemes; calyx 4-parted; stamens 4, inflexed in the bud; pistillate flowers in axillary, pedunculate, capitate clusters; calyx 4-parted, ovary sessile, style long; calyces becoming thickened and fleshy in fruit and aggregated into a large, dense, globular head.

T. POMIFERUM Raf. OSAGE ORANGE. A small tree with ridged, yellowish-brown bark; leaves puberulent when young, becoming smooth and shining with age, ovate or ovate-oblong, acuminate at the apex, obtuse or subcordate at the base, entire, petioled; staminate racemes about 1 in. long; pistillate flower clusters about 1 in. in diameter; fruit yellowish, tubercled, 3–4 in. in diameter. In rich soil. April-May; fruiting in October or November. Native in Texas and extensively planted for hedges. Wood very durable when exposed to the weather, and used for fence posts. As the wood does not swell or shrink with changes in its moisture, it is valued highly for wheel hubs, etc.

III. BROUSSONETIA.

Small trees with milky juice; leaves alternate, petioled; flowers diœcious; staminate in cylindrical spikes, with a 4-cleft calyx, 4 stamens and a rudimentary ovary; pistillate flowers in capitate clusters, calyx 3–4-toothed, ovary stalked, style 2-cleft, fruit in a globular head.

B. PAPYRIFERA (L.) Vent. PAPER MULBERRY. A round-headed tree with yellowish-brown bark; leaves cordate, often irregularly 2–3-lobed, serrate, rough above, tomentose beneath, long-petioled; staminate spikelets peduncled, 2–3 in. long; pistillate heads stout, peduncled, about 1 in. in diameter. April–May. Introduced from Asia and very common about old dooryards.

IV. HUMULUS.

Perennial, herbaceous twining vines with watery juice; leaves opposite, palmately veined; flowers diœcious; staminate flowers in loose axillary panicles, calyx 5-parted, stamens 5, erect in the bud; pistillate flowers in short axillary and solitary spikes, 2 flowers in the axil of each bract; perianth entire, stigmas 2, filiform.

H. Lupulus L. Hop-vine. Stem rough, twining high, leaves rough, palmately 3–7-cleft or lobed, serrate, petiole nearly as long as the leaf; staminate panicles 3–5 in. long, pistillate panicles (hops) $1\frac{1}{2}$–2 in. long in fruit, and then consisting of the greatly enlarged calyces and bracts enclosing the small achenes; fruiting parts sprinkled with yellow, aromatic, resinous grains, which give the hops their peculiar value. June–July.

Ficus carica L., the cultivated fig, also belongs to this family.

28. URTICACEÆ. NETTLE FAMILY.

Herbs with watery juice, stem and leaves often clothed with stinging hairs; undivided, stipulate leaves; small, greenish, imperfect, apetalous flowers in axillary clusters; calyx of the staminate flowers, 4 5-parted or 4–5-sepalous; stamens as many as the sepals and opposite them, filaments inflexed in the bud and straightening at maturity, anthers 2-celled; calyx of pistillate flowers 2–4-sepalous; ovary sessile, 1-celled, stigma simple or tufted; fruit an achene commonly enclosed in the dry, persistent calyx.

I. URTICA.

Annual or perennial herbs; leaves with stinging hairs, opposite, petioled, several-nerved, dentate, or incised, stipulate; flowers monœcious or diœcious; calyx of the staminate flowers 4-parted, stamens 4, inserted around a rudimentary ovary; pistillate flowers with 4 unequal sepals, the inner ones dilated in fruit; achenes smooth, compressed.

1. U. dioica L. Large Stinging Nettle. Perennial; stem and leaves very bristly, stem stout, 2–3 ft. tall, 4-angled, pubescent

above; leaves cordate, acute at the apex, coarsely serrate, 3-nerved, downy beneath, petioles slender, shorter than the blades; stipules lanceolate; flowers in much-branched, panicled spikes, mostly diœcious. June–July. In waste places, especially on rich soil.

2. U. URENS L. SMALL NETTLE. Annual; stem stout, 4-angled, hairy, 12–18 in. tall, with few stinging hairs; branches slender; leaves elliptical or ovate, serrate or incised, 3–5-nerved, acute or obtuse at the ends, thin, hairy, petioles often as long as the blades; stipules short; flower clusters axillary, in pairs, loose, mostly shorter than the petioles. February–May. On damp soil in waste places.

II. BŒHMERIA.

Perennial herbs, with opposite or alternate, petioled, 3-nerved leaves, destitute of stinging hairs; flowers monœcious or diœcious, in axillary clusters, similar to those of Urtica.

B. CYLINDRICA (L.) Willd. FALSE NETTLE. Stem erect, branching, pubescent, 1–3 ft. tall; leaves often opposite and alternate on the same plant, ovate or ovate-lanceolate, acuminate at the apex, rounded and 3-nerved at the base, coarsely serrate with rounded teeth, thin; flowers in axillary spikes; staminate spikes often leafy near the summit, sometimes as long as the leaves; pistillate spikes short, compact. June–July. Common in moist thickets.

29. LORANTHACEÆ. MISTLETOE FAMILY.

Parasitic shrubs or herbs; leaves opposite, coriaceous, without stipules; flowers monœcious or diœcious, clustered or solitary; perianth of both calyx and corolla, or of a calyx only, or sometimes wanting; calyx tube adherent to the ovary, sepals 2–8; stamens as many as the sepals, and opposite them; ovary 1-celled, ovule 1; fruit a berry.

PHORADENDRON.

Evergreen, shrubby plants, parasitic on trees; branches greenish, jointed, and very brittle; leaves coriaceous; flowers diœcious, in short, jointed spikes; staminate flowers globular, calyx 2–4-lobed, stamens sessile at the base of the lobes,

anthers transversely 2-celled; pistillate flowers with the ovary inferior, stigma sessile; berry 1-seeded.

P. FLAVESCENS (Pursh.) Nutt. MISTLETOE. Very round, bushy, branches very brittle at the joints, opposite or whorled, 6 in.–2 ft. long; leaves flat, coriaceous or somewhat fleshy, nearly veinless, obovate, entire, with short petioles; flowering spikes solitary or 2–3 together in the axils of the leaves; berry globose, white, glutinous. April–May. Parasitic on many deciduous trees.

30. ARISTOLOCHIACEÆ. BIRTHWORT FAMILY.

Herbaceous plants, acaulescent or with twining and leafy stems; leaves alternate, exstipulate, petioled, mostly roundish or reniform; flowers axillary, solitary or clustered, perfect, regular or irregular; calyx tubular, 3 or 6-lobed, usually colored; petals none; stamens 6–12, inserted on the ovary; pistils 1, ovary mostly 6-celled, many-seeded.

I. ASARUM.

Perennial, acaulescent, aromatic herbs with slender, branching rootstocks; leaves long-petioled, from reniform to hastate; flowers axillary, peduncled; calyx regular, 3-lobed, withering-persistent; stamens 12, the filaments partially united with the style and usually prolonged beyond the anthers; ovary 6-celled with parietal placentæ, many-seeded; mature capsule globose, often somewhat fleshy.

1. A. VIRGINICUM L. VIRGINIA ASARUM. Leaves evergreen, 1–3 to each plant, glabrous, mottled, round-cordate, entire, 2–3 in. long and broad; petioles glabrous or pubescent along one side, 3–7 in. long; flowers nearly sessile, greenish without, dull purple within, $\frac{2}{3}$–$\frac{3}{4}$ in. long, tube inflated below, narrowed at the throat, lobes spreading. April–May. Rich, shady woods in the upper districts.

2. A. ARIFOLIUM Michx. GINGER-ROOT. Leaves cordate or halberd-shaped, 2–4 in. long, usually mottled; petioles pubescent, 3–8 in. long; flowers pitcher-shaped, about 1 in. long, peduncled, dark purple within, lobes short and rounded. March–April. Shady woods in the lower districts.

II. ARISTOLOCHIA.

Erect or twining perennial herbs or woody vines; leaves alternate, cordate at the base, palmately nerved, petiolate, entire; flowers irregular, solitary or in small clusters; calyx more or less adherent to the ovary, tubular, irregular; stamens mostly 6, sessile, adnate to the angled and fleshy 3–6-lobed or angled stigma; capsule naked, 6-valved, seeds very numerous.

1. A. SERPENTARIA L. VIRGINIA SNAKEROOT. Stem erect, branching, pubescent, 10–18 in. high; leaves short-petioled, ovate to linear-lanceolate, cordate or hastate at the base, thin, smooth; lower leaves scale-like; flowers near the base of the stem on bracted peduncles; calyx tubular, bent like the letter S, inflated below, then contracted, again enlarging at the throat, limb short, spreading, 3-lobed, dull purple; anthers in pairs; capsule subglobose, ridged. June–July. Rich, shady woods. The aromatic-stimulant root often used in medicine.

2. A. TOMENTOSA Sims. DUTCHMAN'S PIPE. Stem woody, climbing high, branches and leaves tomentose; leaves cordate, prominently veined, 3–5 in. long and broad; flowers axillary, mostly solitary, on slender peduncles; calyx bent in the shape of a pipe, yellowish-green with a dark purple throat, limb unequally 3-lobed, rugose, reflexed; anthers in pairs below the 3 spreading lobes of the stigma; .capsule oblong. April–May. Stems sometimes 30 feet long.

31. POLYGONACEÆ. BUCKWHEAT FAMILY.

Herbs, shrubs, or trees; leaves simple, usually entire and alternate, but sometimes opposite; stipules commonly membranaceous, and sheathing the swollen joints of the stem, but sometimes wanting; flowers small, perfect, monœcious or diœcious; calyx of 2–6 sepals which are often more or less united, sometimes petal-like and persistent; petals none; stamens 4–12, inserted on the base of the calyx; ovary single, 1-celled, styles or stigmas 2–3; fruit a lenticular or 3-angled achene.

I. RUMEX.

Annual or perennial herbs, stems grooved, usually branching above; leaves alternate, hastate-lobed or entire; flowers perfect or polygamo-diœcious, in whorls on jointed pedicels; calyx of 6 sepals, the outer 3 being usually colored and petal-like, while the inner 3 form a persistent, winged, 3-valved covering for the fruit; stamens 6; styles 3, stigmas many cleft.

1. R. Acetosella L. Sheep Sorrel. Erect, annual or perennial herbs with creeping rootstocks; stem simple or branched, glabrous; leaves petioled, narrowly hastate, usually widest above the middle, the apex acute or obtuse, upper stem leaves often nearly linear, and not lobed; flowers diœcious, small, in terminal, naked, panicled, interrupted racemes; calyx greenish; the pistillate panicles becoming reddish; fruit less than $\frac{1}{12}$ in. long, granular, longer than the calyx. April–August. A common introduced weed, in dry fields and on sour soils. Foliage very acid.

2. R. verticillatus L. Swamp Dock. Perennial; stem stout, smooth, erect or ascending, 3–5 ft. tall; lower leaves oblong, obtuse at the apex and usually cordate at the base, long-petioled, often 12–18 in. long, upper leaves narrower and often acute at both ends; flowers perfect or polygamous, in dense whorls, pedicels slender, $\frac{1}{2}$–$\frac{2}{3}$ in. long, tapering downward, reflexed at maturity; calyx green, the valves broadly deltoid, abruptly pointed, reticulated, a distinct, long and narrow tubercle on the back of each. May–June. Swamps and wet ground.

3. R. obtusifolius L. Bitter Dock. Perennial; stem erect, stout, branched and somewhat roughened above, 2–4 ft. tall; lower leaves ovate-oblong, obtuse at the apex, cordate at the base, long-petioled; the upper leaves lanceolate or lanceolate-oblong, acute at each end, short-petioled, often wavy on the margin; flowers perfect or polygamous, in open, panicled racemes, the lower whorls scattered, the upper more crowded; pedicels slender, a little longer than the fruit; wings hastate, $\frac{1}{4}$ in. long, with a few spiny teeth on the margins, and at least one of them prominently tubercled on the back. May–August. A common naturalized weed on rich soil.

II. POLYGONUM.

Annual or perennial, terrestrial or aquatic herbs, with tumid joints and simple, alternate, entire leaves; the sheathing stip-

ules (ochreæ) often lacerate or fringed; flowers perfect, usually white or rose-colored, each flower or cluster subtended by a membranaceous bract similar to the ochreæ of the leaves; calyx mostly 5-parted, the divisions petal-like, erect and persistent; stamens 3–9; styles 2–3-parted; fruit lenticular or 3-angled.

1. P. Persicaria L. Lady's Tear-thumb. Annual; stem erect or ascending, simple or branched, nearly or quite smooth, 12–18 in. tall; leaves lanceolate or oblong, short-petioled, roughened on the edges and veins, punctate, usually marked with a dark, triangular spot near the middle; ochreæ bristly ciliate; flowers in erect, densely flowered spikes or racemes 1–2 in. long, rose-color to dark purple, peduncles smooth; achenes lenticular or 3-angled, smooth and shining. June–July. Around dwellings.

2. P. punctatum Ell. Water Smartweed. Perennial; stem creeping and rooting at the base, nearly smooth, slender, 1–3 ft. long; leaves lanceolate or oblong, acuminate at the apex, nearly sessile, rough on the margins and nerves, dotted with pellucid glands; juice acrid; ochreæ oblique, silvery, fringed with long bristles; racemes terminal, slender, loosely flowered, 2–3 in. long; flowers greenish; stamens 8; style 3-parted; achene sharply 3-angled, smooth and shining. June–September. Common in ditches and wet places.

3. P. orientale L. Prince's Feather. Annual; stem hairy, branching above, 3–5 ft. tall; leaves ovate or oblong, acuminate at the apex, ciliate, petioled; ochreæ cylindrical, usually with a spreading border; flowers in long racemes, bright rose-color, showy; stamens 7; style 2-cleft; achene flat, ovate or orbicular, finely reticulated and not shining. June–September. Around dwellings; escaped from cultivation.

4. P. aviculare L. Knot-grass. Annual or perennial; stem prostrate or ascending, diffuse, glabrous, 6–24 in. long; leaves small, lanceolate or linear-oblong, obtuse, nearly or quite sessile; ochreæ scarious, 2–3-cleft or lacerate; flower clusters axillary, 1–5-flowered, flowers inconspicuous, nearly sessile; calyx greenish-white, 5-parted, the lobes with white or colored borders; stamens 5–8; style 3-parted; achene 3-angled, not shining. May–September. A common weed in dooryards and where the ground is tramped.

5. P. dumetorum L. False Buckwheat. Perennial; stems slender, twining, branched, 2–10 ft. long; leaves ovate, acuminate at the apex, cordate to halberd-shaped at the base, long-petioled; ochreæ cylindrical, truncate; flowers in axillary, more or less compound and leafy racemes; calyx greenish-white, the outer lobes winged and decurrent on the pedicel; stamens 8; stigmas 3; achene 3-angled,

black, smooth and shining. May–September. Margins of fields and thickets.

6. P. hirsutum Walt. Hairy Smartweed. Perennial; stems erect, branching, hirsute with spreading hairs, 2–3 ft. tall; leaves lanceolate, rounded at the base, hairy, especially on the margins and veins, nearly sessile; ochreæ hirsute, margin with a fringe of long hairs; flowering spike linear, erect, rather closely flowered; calyx white; stamens 8; achene 3-angled. June–August. Common about ponds in pine barrens.

III. BRUNNICHIA.

Perennial; stem smooth, climbing by tendrils at the ends of the branches; leaves alternate, entire, petioled; ochreæ small or wanting; flowers greenish, in axillary and terminal racemes, on slender pedicels; calyx 5-parted, becoming much enlarged, and almost woody in fruit; stamens usually 8; styles 3; mature achene 3-angled, enclosed by the persistent calyx.

B. cirrhosa Banks. Brunnichia. Stem somewhat woody, climbing 15–20 ft.; leaves ovate or cordate, slightly pubescent beneath; sheaths obsolete; racemes drooping, 2–6 in. long; flowers in clusters of 2–5, pedicels recurved; mature fruit coriaceous, 1 in. or more in length. April–May. River banks.

32. CHENOPODIACEÆ. GOOSEFOOT FAMILY.

Annual, or perennial by a slightly woody rootstock; leaves simple, alternate or opposite, exstipulate; flowers perfect, polygamous, monœcious or diœcious, small, greenish, sometimes irregular, occasionally solitary in the axils but usually in panicled spikes; calyx 2–5-lobed or sometimes a single sepal; petals none; stamens as many as the lobes of the calyx and opposite them, or sometimes fewer; ovary free from the calyx, 1-celled, styles 1–3; fruit a utricle. A family containing many common weeds, some of which are immi-

grants from tropical countries, and also the common garden beet (*Beta vulgaris*), which is a native of Europe.

I. CHENOPODIUM.

Annual or perennial herbs; stems erect or diffuse; leaves alternate, usually white-mealy; flowers small, greenish, in panicled spikes; calyx 3–5-parted, the lobes often slightly fleshy and keeled; stamens 5, filaments filiform; styles 2–3, distinct or united at the base; seed lenticular.

1. C. ALBUM L. PIGWEED. Annual; stem erect, branching, striate or furrowed, 1–5 ft. tall; leaves rhombic-ovate, acute at the base, irregularly toothed, or the upper becoming narrower and entire, more or less coated with white powder; petiole nearly as long as the blade; flowers in small, panicled spikes; calyx 5-angled, sepals strongly keeled; seed black and shining. June–September. A common weed in cultivated ground.

2. C. ANTHELMINTICUM L. WORMSEED. Perennial; stem stout, erect, much branched, 2–4 ft. tall; leaves oblong or lanceolate, acute at each end, coarsely and sharply toothed or incised, upper leaves smaller; flowers very numerous, in linear, panicled spikes which are often leafy-bracted; calyx not keeled; seeds with obtuse margins, smooth and shiny; whole plant very aromatic-fragrant. July–September. In waste places.

II. SALICORNIA.

Herbs, annual or perennial; stems fleshy, glabrous, branches opposite, jointed; leaves reduced to small, opposite scales; flowers perfect, 3–6 together, sunken into the upper joints of the stem, forming terminal spikes; calyx thin, becoming spongy in fruit; stamens 1–2; styles or stigmas 2; fruit a utricle enclosed in the spongy calyx; whole plant salty to the taste.

1. S. AMBIGUA Michx. GLASSWORT. Perennial; stem slightly shrubby at the base, the branches ascending or erect, nearly simple, joints truncate, dilated above, slightly 2-toothed; fruiting spikes cylindrical or obtuse, $\frac{1}{2}$–$1\frac{1}{2}$ in. long, the terminal ones sessile, the lateral peduncled. July–September. Salt marshes along the coast.

III. SALSOLA.

Herbs, annual or perennial; stems diffusely branched; leaves alternate, fleshy; flowers solitary in the axils, sessile, perfect, 2-bracted; calyx 5-parted, the lobes becoming winged; stamens 5; style slender, stigmas 2; utricle flattened at the apex, enclosed in the persistent calyx.

S. Kali L. Saltwort. Annual; stem very diffuse, smooth or slightly pubescent, 1–2 ft. high; leaves dull or grayish-green, succulent, subulate, spine-tipped, ½–1 in. long; flowers solitary in the axils; the calyx with a dilated, membranaceous, rose-colored wing. June–September. Sandy sea beaches.

33. AMARANTACEÆ. AMARANTH FAMILY.

Usually herbs, or a few species becoming shrubby; leaves simple, alternate or opposite, exstipulate; flowers perfect or imperfect, mostly greenish and inconspicuous and crowded in bracted spikes or heads; sepals 3–5, free or united at the base; petals none; stamens 1–5, opposite the sepals, filaments distinct or united; pistil 1, ovary subglobose, 1-celled, 1-seeded; fruit a utricle, usually circumscissile.

I. AMARANTUS.

Herbs, annual; stems erect or diffuse; leaves alternate, usually petioled, entire and mucronate; flowers greenish or purplish, crowded in dense axillary and terminal spikes or clusters; sepals 2–5, distinct; stamens 2–5; stigmas 2–3, recurved; utricle 2–3-toothed at the apex, circumscissile, usually enclosed by the calyx.

1. A. hybridus L. Slender Pigweed. Annual; stem smooth or nearly so, erect, branching, 2–6 ft. tall, often purplish; leaves ovate or ovate-oblong, obtuse, notched or tapering at the apex, mucronate, pale beneath, petioles long and slender; flowering spikes numerous, panicled, the terminal one long and slender, the others shorter; sepals acuminate, shorter than the subulate bracts; utricle

slightly rugose. July–October. An introduced weed in waste ground.

2. A. SPINOSUS L. SPINY AMARANTH. Annual; stem smooth or slightly pubescent above, stout, erect, much branched, succulent, 1–3 ft. tall; leaves ovate or lanceolate, acute at both ends or sometimes emarginate at the apex, blotched with purple above, long-petioled, spiny in the axils; flowers in numerous capitate, nearly sessile clusters, the bracts, sepals, and utricle about equal in length. June–October. A troublesome weed from tropical America.

II. FROELICHIA.

Herbs, annual; stems slender, erect, branching above, woolly; leaves opposite, entire, exstipulate; flowers in dense spikes terminating the peduncle-like branches, perfect, 3-bracted; calyx tubular, 5-cleft, becoming spiny-tipped in fruit; stamens 5, united into a tube; ovary ovoid, stigma capitate or lacerate-fringed; fruit a 1-seeded utricle enclosed by the calyx.

F. FLORIDANA (Nutt.) Moq. FROELICHIA. Stem 1–4 ft. tall, white-woolly, erect, branched and leafless above; lower leaves spatulate to lanceolate, long-petioled; stem-leaves sessile and usually linear, entire; flowering spikes from opposite branches, lengthening with age; bracts blackish; calyx very white-woolly. June–September. Dry, sandy ground, especially near the coast.

34. PHYTOLACCACEÆ. POKEWEED FAMILY.

Herbs or shrubs; leaves simple, alternate, entire, exstipulate; flowers in spikes or racemes; calyx of 4–5 distinct sepals or 4–5-parted; petals none; stamens as many as the sepals and alternate with them, or more numerous; pistil 1, simple or compound, ovules 1 in each cell; fruit (in our species) a berry.

PHYTOLACCA.

Perennial herbs; stems tall, branching; leaves large, entire; flowers small, in terminal racemes, pedicels bracted; calyx of 4–5 nearly equal, persistent sepals; stamens 5–15, inserted at the base of the calyx; styles 5–12, recurved at the apex; fruit a depressed-globose, juicy berry.

P. DECANDRA L. POKEWEED. Stems erect, smooth, branched above, usually dark purple, 4–7 ft. tall; root large, fleshy, poisonous; leaves ovate-lanceolate, smooth, acute, long-petioled; racemes peduncled, many-flowered, opposite the leaves, flowers white, becoming purplish; stamens 10, shorter than the sepals; styles 10, carpels 10; fruit a dark purple berry. June–September. A weed on waste ground. The young branches are often eaten like asparagus, and the root, known as "garget root," is used in medicine.

35. PORTULACACEÆ. PURSLANE FAMILY.

Herbs; stems fleshy or succulent; leaves alternate or opposite; flowers perfect, regular, unsymmetrical; sepals commonly 2, sometimes 5; petals 3–6, hypogynous, entire or emarginate; stamens hypogynous, as many as the petals and opposite them, or indefinite; pistil 1, styles 3–6, mostly united below, ovary 1–5-celled, few–many-seeded; fruit a membranaceous, circumscissile capsule.

I. CLAYTONIA.

Perennial; stem simple, smooth, erect, 4–10 in. high; leaves 2, opposite, smooth, succulent; flowers in a terminal raceme; sepals 2, ovate, persistent; petals 5, sometimes coherent at the base; stamens 5, inserted on the base of the petals; style 3-cleft, ovary 1-celled, 3–6-seeded.

C. VIRGINICA L. SPRING BEAUTY. Stem simple, erect from a deep, tuberous root; the 2 stem-leaves narrowly elliptical, 3–6 in. long, smooth, fleshy; basal leaves occasionally produced; flowers

on short pedicels, petals white or pink, with darker veins, $\frac{1}{4}$–$\frac{3}{8}$ in. long, emarginate; capsule shorter than the persistent sepals. March–April. Common in rich woods.

II. PORTULACA.

Annual; stems low, diffuse and spreading, succulent; leaves entire, mostly alternate; flowers terminal; sepals 2, united at the base and coherent with the ovary; petals usually 5, inserted on the calyx, fugacious; stamens 8–20, inserted on the calyx; style 3–8-parted, capsule globose, 1-celled, many-seeded.

1. P. OLERACEA L. PURSLANE. Stems prostrate, diffuse, fleshy; leaves alternate, flat, obovate or cuneate; flowers solitary, sessile, opening in bright sunshine in the morning, and usually withering before noon; sepals broad, acute; petals yellow; stamens 10–12; capsule very many-seeded, seeds small, rugose. April–October. A common garden weed.

2. P. GRANDIFLORA Hook. GARDEN PORTULACA. Stems succulent, erect or ascending, densely hairy or nearly smooth, 3–6 in. long; leaves alternate, terete, fleshy, $\frac{1}{2}$–1 in. long; flowers 1–2 in. wide, white, yellow, or red, showy, opening only in sunlight. The summer months. Common in cultivation and often growing spontaneously.

36. CARYOPHYLLACEÆ. PINK FAMILY.

Annual or perennial herbs; stems tumid at the nodes; leaves opposite or whorled, often connate, entire; stipules dry and scarious or none; flowers cymose, usually perfect; sepals 4–5, persistent, distinct or united into a tube; petals as many as the sepals or none; stamens as many as the sepals and opposite them, or twice as many, or sometimes fewer; ovary 1, free, usually 1-celled, sometimes 3–5-celled, placentæ central, styles 2–5; fruit dry, 1–many-seeded.

I. AGROSTEMMA.

Annual; stem pubescent, branching above; leaves linear-lanceolate or linear, pubescent, sessile; flowers showy, on

long and naked peduncles in terminal corymbs; calyx tubular, the tube oblong, 10-ribbed, lobes elongated, foliaceous, deciduous; petals 5, shorter than the calyx lobes, entire; stamens 10; styles 5, capsules 1-celled.

A. Githago L. Corn Cockle. Stem erect, rather slender, 1–3 ft. tall, gray with long, appressed hairs; leaves linear-lanceolate, acuminate, erect, 2–4 in. long; petals obovate, emarginate, purple; capsule 5-toothed, many-seeded, seeds black. June–July. An introduced weed, common in grain fields.

II. SILENE.

Annual or perennial herbs; stems erect, or decumbent and diffuse; leaves often connate or whorled; flowers clustered or solitary, usually pink or white; calyx tubular, more or less inflated, 5-toothed, 10-nerved, bractless; petals 5, long-clawed, and, with the ten stamens, inserted at the base of the ovary; styles 3, ovary 1-celled or 3-celled at the base, opening by 6 teeth, many-seeded, seeds usually roughened.

1. S. stellata (L.) Ait. Starry Campion. Perennial; stems erect, downy, branching above, 2–3 ft. tall; leaves in whorls of 4, or the upper opposite, ovate-lanceolate, acuminate, sessile, ciliate on the margins; flowers in panicled cymes, white, $\frac{3}{4}$ in. broad; calyx inflated, bell-shaped, the teeth triangular; petals fimbriate on the margin, crownless. June–July. Dry fields and woods, especially northward.

2. S. Baldwinii Nutt. Baldwin's Pink. Perennial; stems low, slender, villous, producing long runners from the base, 6–12 in. high; leaves opposite, spatulate or oblong, sessile; flowers large, $1\frac{1}{2}$–2 in. wide, white or pale rose-colored, on slender pedicels; calyx tubular; petals fimbriate on the margins, crownless. April–May. In low shady woods, especially southward.

3. S. regia Sims. Royal Catchfly. Perennial; stem stout, erect, viscid-pubescent, branched, 2–4 ft. tall; leaves ovate-lanceolate, acute or acuminate, the lower petioled, the upper sessile; flowers in a narrow panicle, bright scarlet, 1 in. broad, pedicels about $\frac{1}{2}$ in. long; calyx cylindrical, striate, enlarged by the ripening capsule, teeth ovate, acute; petals emarginate or nearly entire, crowned; stamens and style exserted. June–July. Open woods and prairies.

III. SAPONARIA.

Annual or perennial; stems erect or diffuse; leaves usually broad; cymes densely flowered; calyx tubular, striate, 5-toothed; petals 5, entire, appendaged; stamens 10; styles 2; capsule 1-celled, 4-toothed at the apex.

S. OFFICINALIS L. BOUNCING BET. Perennial; stems stout, smooth, erect, sparingly branched, 1–2 ft. tall; leaves ovate, acute, strongly 3–5-ribbed, petioles short, broad and somewhat connate; flowers pink or white, 1 in. broad, showy, often double; petals obcordate, crowned; capsule shorter than the calyx. May–July. Naturalized about old gardens.

IV. DIANTHUS.

Mostly perennial; stems erect, rigid; leaves narrow, and usually connate; flowers terminal, solitary or in cymose clusters; calyx several-bracted at the base, tubular, striate, 5-toothed; petals 5, long-clawed, dentate or crenate; stamens 10; styles 2, ovary 1-celled, raised on a short stipe; capsule cylindrical.

D. BARBATUS L. SWEET WILLIAM. Perennial, often in large clumps; stems erect, branching above, smooth, 1–2 ft. tall; leaves lanceolate, 2–3 in. long, acute; flowers pink or white, in terminal clusters, bracts linear, as long as the calyx. May–August. Common about old gardens.

V. CERASTIUM.

Annual or perennial; stems diffuse, usually pubescent; leaves opposite; flowers white, peduncled, in terminal, regularly forking cymes; sepals 4–5; petals 4–5, emarginate or 2-cleft; stamens 10; styles 5 or less; capsule cylindrical, 1-celled, many-seeded.

C. VULGATUM L. MOUSE-EARED CHICKWEED. Annual or sometimes perennial; stems diffuse, tufted, clammy-pubescent, 6–12 in. high; lower leaves spatulate, the upper oblong, acute or obtuse; bracts scarious; flowers in loose cymes, pedicels becoming much longer than the calyx; sepals lanceolate, acute, about as long as the 2-cleft petals; slender capsule becoming twice as long as the calyx and curved upward. April–May. A common garden weed.

37. NYMPHÆACEÆ. WATER-LILY FAMILY.

Perennial aquatic herbs; rootstocks creeping in mud; leaves entire, peltate or cordate, usually floating on the surface of the water; flowers solitary on long peduncles; sepals 3-5; petals 5-many; ovary 1, many-celled; seeds often enclosed in a pulpy aril.

I. NYMPHÆA.

Rootstock horizontal, thick, cylindrical; leaves cordate, floating or erect; flowers yellow; sepals 4–6, green on the outside, obovate, concave; petals many, hypogynous, the inner ones becoming small and stamen-like; stamens many, hypogynous; ovary cylindrical, many-celled, stigma disk-shaped; fruit ovoid, seeds without an aril.

N. ADVENA Sol. YELLOW POND LILY. Leaves oval or orbicular, rather thick, often pubescent beneath; flowers bright yellow, 2–3 in. in diameter, depressed-globose; sepals 6; petals thick and fleshy, truncate; stamens in several rows, anthers nearly as long as the filaments. April–September. In slow streams and still water.

II. CASTALIA.

Rootstock horizontal, creeping extensively; leaves floating, entire, peltate or cordate; flowers showy; sepals 4, green without, white within; petals many, white, becoming smaller toward the center; stamens many, the outer with broad and the inner with linear filaments; ovary many-celled, stigmas peltate and radiating; fruit baccate, many-seeded.

C. ODORATA (Dryand) W. & W. WHITE WATER-LILY. Rootstock large, branched but little; leaves floating, entire, the sinus narrow and basal lobes acute, green and smooth above, purple and pubescent beneath; petioles and peduncles slender; flowers white, very fragrant, opening in the morning, 3–5 in. broad; fruit globose, seeds enclosed in a membranaceous aril. May–July. In ponds and still water.

III. NELUMBO.

Rootstock thick, creeping; leaves orbicular, centrally peltate, concave above, raised above the water or floating; flowers solitary on long peduncles, raised above the water at flowering, but the maturing ovaries often submersed; flowers hypogynous; sepals and petals similar, numerous; filaments somewhat petal-like; seeds in pits in the upper surface of the top-shaped receptacle.

N. LUTEA (Willd.) Pers. AMERICAN LOTUS. Rootstock often 3–4 in. in diameter, horizontal; leaves $1\frac{1}{2}$–$2\frac{1}{2}$ ft. broad, prominently ribbed, very glaucous above, often pubescent beneath; petioles and peduncles stout; flowers pale yellow, 5–9 in. broad; sepals and petals falling quickly; fruit top-shaped, 3–4 in. in diameter; the seeds $\frac{1}{2}$ in. in diameter, immersed in pits in the upper surface. May–August. In ponds; introduced from the southwest.

38. MAGNOLIACEÆ. MAGNOLIA FAMILY.

Trees or shrubs; all parts more or less aromatic; leaves alternate, simple, petioled, entire or lobed; flowers solitary, large and showy, hypogynous; sepals and petals in 3's; stamens many; ovaries numerous, usually cohering over the elongated receptacle; fruit dry or fleshy.

I. MAGNOLIA.

Aromatic trees or shrubs; leaves alternate, often in clusters at the ends of the branches, entire, usually thick and leathery; stipules large, quickly deciduous; flowers terminal, showy, perfect; sepals 3, caducous; petals 6–12, in 2–4 rows, concave; stamens numerous; ovaries numerous, 1-celled, 2-seeded, the mature follicles opening at the beak and the fleshy seeds remaining for some time suspended by slender threads.

1. M. FŒTIDA (L.) Sarg. LARGE-FLOWERED MAGNOLIA. A large tree with spreading branches and a rounded top; bark nearly smooth; leaves very thick, evergreen, smooth and shining above,

rusty-pubescent beneath, entire, oval or oblong, 6–9 in. long; flowers white, very fragrant, 6–9 in. in diameter; petals 9 or more, obovate, concave; fruit a rusty-pubescent cone 3–4 in. long, seeds bright scarlet. April–June. Common on light soils. The name is very inappropriate, as the fragrance is delightful and the tree one of the most attractive native species.

2. M. FRASERI Walt. LONG-LEAVED UMBRELLA TREE. A small tree with a slender trunk and widely spreading branches; leaves clustered at the ends of the branches, deciduous, oblong or obovate, contracted, cordate and auricled at the base, smooth on both sides, 8–12 in. long; petioles slender; flowers white and fragrant, 6 in. broad; petals longer than the sepals, spatulate or oblong, obtuse at the apex, narrowed at the base; cone 3–4 in. long, pink at maturity. May–June. In rich woods.

3. M. MACROPHYLLA Michx. LARGE-LEAVED UMBRELLA TREE. A small tree with gray bark; leaves clustered at the ends of the branches, oblong or obovate, obtuse at the apex, cordate at the base, green and glabrous above, white and pubescent beneath, $1\frac{1}{2}$–3 ft. long; petioles stout; flowers white with a purple center, fragrant, 8–12 in. wide; petals oblong, obtuse, two or three times as long as the sepals; cone ovate, 4–6 in. long, bright red at maturity. April–May. Shady woods on light soil.

4. M. VIRGINIANA L. SWEET BAY. A small tree with light gray bark; leaves scattered on the branches, evergreen, thick and leathery, oval or oblong, smooth and green above, white and glaucous or pubescent beneath, 4–6 in. long; flowers white, fragrant, 2–3 in. in diameter; petals 9, concave; cone $1\frac{1}{2}$–2 in. long, pink. May–June. Common in swamps and along streams. The leaves often used in flavoring soups, etc.

II. ILLICIUM.

Aromatic shrubs; leaves evergreen, clustered at the ends of the branches, entire, exstipulate; flowers perfect; sepals 3 or 6; petals 9–30 in rows of 3; stamens numerous, short; ovaries 6–9, whorled, 1-celled, 1-ovuled, at length spreading.

I. FLORIDANUM Ellis. ANISE. A slender, spreading shrub, 5–10 ft. high; bark reddish-brown; leaves leathery, oblong-lanceolate, acute, smooth, 4–6 in. long; flowers on long peduncles in terminal clusters; petals many, lanceolate or linear, spreading, dark purple, $\frac{1}{2}$–$\frac{2}{3}$ in. long; mature fruit a whorl of 12–20 divergent, 1-seeded follicles. April–May. In sandy swamps. Whole plant very aromatic.

III. LIRIODENDRON.

A large tree with rough, dark-colored bark; leaves scattered on the branches, deciduous, 3-lobed, truncate, stipulate, petioled; flowers perfect; sepals 3, reflexed; petals 6, erect; stamens numerous; ovaries numerous, 2-ovuled, cohering over each other on the elongated receptacle, indehiscent, deciduous.

L. TULIPIFERA L. TULIP TREE. The largest tree in the family; leaves orbicular in outline, mostly 3-lobed, the terminal lobe truncate or broadly notched, usually cordate at the base, glabrous, green above, lighter beneath; petioles slender; flowers terminal, bell-shaped, greenish-yellow striped with orange; petals obovate, obtuse, about as long as the sepals; mature cones ovate, acute, 2–3 in. long. May–June. Common on low ground. Often called "white wood" or, incorrectly, "white poplar." Wood valuable for making boxes and light furniture.

39. ANONACEÆ. CUSTARD-APPLE FAMILY.

Trees or shrubs with simple, alternate, entire, exstipulate leaves; flowers perfect, axillary, solitary, hypogynous; sepals 2–3, persistent; petals 6, in 2 rows, deciduous; stamens many; ovaries few or many, distinct or coherent, becoming fleshy in fruit.

ASIMINA.

Shrubs or small trees; leaves deciduous; flowers nodding; sepals 3, ovate; petals 6, the three outer ones larger and spreading; stamens very numerous, crowded on the globular receptacle; ovaries 3–15, sessile, 1-celled, several-ovuled; fruit a large, fleshy, oblong berry, seeds large, horizontal.

1. A. TRILOBA (L.) Dunal. PAWPAW. A small tree, 10–20 ft. high; bark nearly smooth, lead-colored; leaves oblong-obovate, acute at the apex, obtuse at the base, rusty-pubescent when young and becoming smoother with age, 6–10 in. long; flowers on branches of the previous season, appearing before or with the leaves; the short peduncles and the sepals brown-pubescent; petals purple, obovate, 3–4 times longer than the sepals; fruit 3–5 in. long, edible when ripe. March–April. Common on banks of streams. The bark is very tough and is often used in the place of rope.

2. A. PARVIFLORA (Michx.) Dunal. DWARF PAWPAW. A shrub 2–4 ft. high; leaves oblong-obovate, abruptly acute, rusty-pubescent when young; flowers greenish-purple, on shoots of the previous season; outer petals obovate, twice the length of the sepals, the inner petals narrower and shorter; fruit oblong or pear-shaped, few-seeded, not edible. March–April. In dry woods.

40. RANUNCULACEÆ. CROWFOOT FAMILY.

Herbs or woody climbing vines, with a watery, acrid juice; leaves alternate, usually divided or compound; petioles dilated at the base; stipules none; flowers perfect, regular or irregular, hypogynous; sepals 3–15, deciduous, often petal-like; petals 5–15, deciduous, often wanting; stamens many; ovaries distinct, usually numerous, but sometimes few, 1-celled, 1–many-seeded; fruit dry or fleshy.

Flowers irregular	V. Delphinium.
Flowers regular.	
Fruit a berry	III. Actæa.
Fruit an achene.	
Achenia plumose-tailed	IX. Clematis.
Achenia ribbed.	
Flowers perfect	VIII. Syndesmon.
Flowers imperfect	XI. Thalictrum.
Achenia not ribbed.	
Sepals petaloid.	
Involucre near the flower . . .	VII. Hepatica.
Involucre remote	VI. Anemone.
Sepals herbaceous	X. Ranunculus.
Fruit a 2-seeded follicle	II. Isopyrum.
Fruit several-seeded follicles .	
Follicles 2	XII. Pæonia.
Follicles 5 or more.	
Leaves simple	I. Caltha.
Leaves compound	IV. Aquilegia.

I. CALTHA.

Perennial aquatic herbs; leaves undivided; sepals 5–9, petal-like; petals none; pistils 5–15, stigmas sessile; ovaries many-seeded.

C. PALUSTRIS L. MARSH MARIGOLD. Stem thick, smooth, hollow, furrowed, 10–15 in. high; leaves long-petioled, round or broadly reniform, smooth, thick, toothed or nearly entire; flowers bright yellow, showy, 1½ in. broad; stamens numerous; follicles oblong, pointless, compressed, many-seeded. April–May. In wet meadows and swamps. More common northward.

II. ISOPYRUM.

Perennial from small tubers; stem slender, smooth; leaves alternate, compound; flowers axillary and terminal, solitary, white; sepals 4–6; petals minute or wanting; pistils 2–20; follicles sessile, 2-seeded.

I. BITERNATUM T. & G. SPRING BEAUTY. Stem erect, rarely branched, 6–10 in. high; radical leaves on long petioles, twice 3-compound; stem leaves sessile, ternate; leaflets ovate or obovate, 2–3-lobed; flowers white, 1 in. wide; sepals oval, petal-like; petals none; stamens many; pistils 3–6; follicles spreading at maturity, pointed. April–May. Shady woods. Resembling *Syndesmon thalictroides* in general appearance, but distinguished by the ovary being 2-seeded.

III. ACTÆA.

Perennial; stem simple; leaves 2–3-ternate; leaflets ovate, sharply cut or toothed; flowers white, in a short and thick terminal raceme; sepals 4–5, soon deciduous; petals 4–10, small; pistil single, stigma 2-lobed; fruit a many-seeded berry.

A. ALBA Bigel. BANEBERRY. Stem erect, smooth or nearly so, 18–24 in. high; leaves large and spreading; leaflets thin; racemes very broad; petals slender, truncate; pedicels red, thickened in fruiting; berries white. May–June. In rich woods; more common in the mountain regions.

IV. AQUILEGIA.

Perennial herbs; stems erect, branching, 1–2 ft. high; leaves compound; flowers showy, nodding; sepals 5, colored; petals 5, prolonged downward as a hollow, curved spur; stamens numerous, the inner ones longer; pistils 5; follicles many-seeded.

1. A. Canadensis L. Columbine. (Sometimes wrongly called honeysuckle.) Stems several or many in a clump, branching, smooth or slightly pubescent, leafy; radical leaves long-petioled, biternate; stem leaves short-petioled, ternate; leaflets roundish or obovate, lobed; flowers terminal or somewhat corymbed, large and showy, scarlet and yellow; sepals ovate, acute; petals horn-shaped, attached by one edge of the mouth; stamens and styles exserted; follicles erect and somewhat divergent at maturity. April–May. Rocky woods and river banks.

2. A. vulgaris L. European Columbine. Very similar to *A. Canadensis*, but with spurs shorter and more curved, and the stamens less exserted; flowers white, blue, or purple, and often double. Common in cultivation.

V. DELPHINIUM.

Annual or perennial herbs; stem erect, simple, or branched; leaves alternate, petioled, palmately divided; flowers in terminal racemes or panicles, showy; sepals 5, colored, irregular, the upper one prolonged into a spur; petals 4, unequal, the two upper ones with long spurs which are enclosed in the spur of the upper sepal, the other two short-stalked; pistils 1–5, ovaries many-seeded.

1. D. azureum Michx. Blue Larkspur. Perennial; stem usually simple, slender, downy, 1–2 ft. high; leaves 2–3 in. wide, 3–5-parted, the divisions cleft into 3–5 narrow, toothed, or entire lobes; flowers in a strict, many-flowered, terminal raceme, showy, blue, spur ascending, curved; lower petals bearded, 2-cleft; pods erect. April–June. On rich soil in open places.

2. D. Consolida L. Garden Larkspur. Annual; stem branching, 3–4 ft. high; leaves cut and divided into narrowly linear lobes; racemes loosely flowered; flowers blue; petals somewhat united; pistil single. June–September. Introduced and naturalized in many places.

VI. ANEMONE.

Perennial herbs, with naked stems bearing opposite or whorled and divided leaves which form an involucre below the flowers; sepals 4–20, petal-like, soon deciduous; petals none; stamens very numerous; achenia capitate, pointed, or tailed.

1. A. NEMOROSA L. WOOD ANEMONE. Stem simple, from a slender rootstock, smooth or slightly pubescent, 4–6 in. high, bearing a single flower about 1 in. broad; leaves 3, long-petioled, trifoliate, the divisions ovate-lanceolate or wedge-shaped, toothed, lobed or parted, about as long as the peduncle; sepals 4–6, oval, white or often purple-tinged on the outside; achenia 15–20, with a hooked beak. March–April. Common in open woods.

2. A. CAROLINIANA Walt. CAROLINA ANEMONE. Stem simple, from a roundish tuber, slightly pubescent, 6–12 in. high, bearing a single flower about 1 in. broad; root leaves 2–3, long-petioled, ternate, the divisions cut or lobed; stem leaves sessile, ternate, the divisions cuneate; sepals 12–20, white; head of fruit becoming oblong; achenia woolly. March–April. In open woods.

3. A. VIRGINIANA L. VIRGINIA ANEMONE. Stems at first simple, but finally bearing several long peduncles which may be again forked, hairy or woolly, 2–3 ft. high; leaves of the first involucre 3, on long petioles, 3-parted, those of the secondary involucres 2, the divisions toothed or lobed; root leaves 2–4, similar to those of the involucres; flower $\frac{2}{3}$–$\frac{3}{4}$ in. wide; sepals 5, greenish-white, oval, acute; achenia woolly, in an oblong head. June–September. In open woods and fields.

VII. HEPATICA.

Perennial herbs, with flowers and fruit like those of Anemone, but with simple stems and with the 3-leaved involucre so close to the flowers as to resemble a calyx.

H. TRILOBA Choix. LIVER-LEAF. Stem erect, hairy, 3–6 in. high; involucre of 3 ovate, entire, sessile leaves; radical leaves long-petioled, 3-lobed, lobes entire; sepals 6–9, blue, purplish or white; flowers about 1 in. wide; achenia several, ovate, pointed, hairy. February–March. In rich, shady woods.

VIII. SYNDESMON.

Small, perennial herbs; leaves decompound, glabrous, those from the root long-petioled, those of the stem sessile; flowers in a terminal umbel, slender pediceled; sepals petaloid; petals none; pistils 4–15, stigmas sessile, truncate.

S. THALICTROIDES (L.) Hoffm. RUE ANEMONE. Stem slender, 6–10 in. high, from a cluster of tuberous roots; radical leaves long-petioled, biternate, leaflets oval, cordate, 3–5-lobed; stem leaves 2–3-ternate, whorled, the long-stalked leaflets veiny, forming an involucre of 6–9 apparently simple leaves; flowers 3–6 in an umbel, $\frac{1}{2}$–$\frac{3}{4}$ in. wide; sepals 6–10, white. March–May. In rich woods.

IX. CLEMATIS.

Perennial herbs or slightly woody vines, usually climbing by the leaf stalks; leaves opposite, simple or compound; sepals 4, petal-like; petals very small or wanting; pistils numerous, tipped by the persistent styles which often become long and plumose in fruit.

1. C. CRISPA L. MARSH CLEMATIS. Stem climbing, a little woody below, slightly pubescent above, 3–5 ft. high; leaves pinnately compound; leaflets 5–7, varying from lanceolate to ovate, thin, entire or 3–5 lobed; flowers showy, perfect, solitary, on long, axillary peduncles; sepals lanceolate, acuminate, thick, wavy on the margins, twice the length of the stamens, light bluish purple, 1–1$\frac{1}{2}$ in. in length; tails of the ripened achenia 1 in. long, silky. March–September. Rich woods and river banks.

2. C. VIRGINIANA L. VIRGIN'S BOWER. Stem somewhat woody, climbing over shrubs and trees; leaves ternately compound; leaflets ovate, acute, lobed, cordate at the base, 2–3 in. long, smooth; flowers numerous, in axillary, panicled clusters, diœcious or polygamous; sepals obovate, hoary, spreading, white; tails of the achenia plumose, showy, 1 in. or more in length. June–July. River banks and meadows.

3. C. VIORNA L. LEATHER FLOWER. Stem climbing, nearly smooth, 6–10 ft. long; leaves usually pinnately compound, the lowest pair often ternate and the upper pair simple; leaflets usually 5–7, oblong-ovate or oval, acute, firm, entire or lobed; calyx bell-shaped, nodding; sepals ovate, acuminate with a short, recurved

point, thick and leathery, reddish-purple, 1 in. long; tails of the achenia plumose, 1½ in. long, brownish. May–August. On river banks and rich soil.

X. RANUNCULUS.

Annual or perennial herbs; leaves alternate, usually deeply lobed or parted; flowers axillary or in corymbs, white or yellow; sepals 3–5; petals 3–5, flat, with a small pit or scale inside at the narrowed base; stamens usually numerous; pistils few or several in a head; achenia flattened, pointed; mostly growing in wet soil.

1. R. PARVIFLORUS L. SMALL-FLOWERED BUTTERCUP. Annual; stems erect, branched, downy, 6–12 in. high; leaves small, the lower orbicular, 3-lobed, sharply toothed, the upper 3–5-parted or entire; flowers very small; sepals reflexed; petals yellow, as long as the sepals; achenia margined, rough, with a recurved beak. April–May. Wet, waste places.

2. R. PUSILLUS Poir. LOW SPEARWORT. Perennial; stems several, erect or ascending, branched, glabrous, 6–15 in. high; leaves entire or slightly toothed, the lower round or cordate, long-petioled, the upper lanceolate or elliptical, nearly or quite sessile; flowers very small, about $\frac{1}{6}$ in. wide, yellow; petals 1–5, as long as the sepals; stamens 3–10; achenia smooth, with a very short point. March–April. On muddy banks.

3. R. ABORTIVUS L. SMALL-FLOWERED CROWFOOT. Perennial; stems glabrous, branching, 12–18 in. high; root leaves round-cordate, crenate, petioled; stem leaves 3–5-parted, with wedge-shaped or linear divisions, sessile; flowers very small, pale yellow; sepals reflexed, longer than the petals; achenia in a globose head, smooth, with a short, recurved beak. March–April. Common on wet ground.

4. R. RECURVATUS Poir. HOOKED CROWFOOT. Perennial; stem erect, hirsute, 1–2 ft. high; leaves all nearly alike, petioled, 3–5-lobed with the lobes wedge-shaped, cut or toothed at the apex; flowers small, pale yellow; petals minute, shorter than the reflexed sepals; achenia in a globular head, smooth, with a long and slender recurved beak. April–May. On low ground.

5. R. PENNSYLVANICUS L. BRISTLY CROWFOOT. Perennial; stems rough-hairy, erect, 2–3 ft. high; leaves ternate, on long and very hairy petioles; leaflets long-stalked, 3-parted, the divisions sharply lobed or toothed; flowers small; petals yellow, shorter than the sepals; achenia flat, smooth, in oblong heads, beak broad and straight. May–June. On low ground; more common northward.

6. R. REPENS L. CREEPING CROWFOOT. Perennial; stems sometimes erect, 5–10 in. high, but usually forming long runners, smooth or hairy; leaves ternate or 3-parted, the divisions stalked, 3-cleft or toothed; flowers bright yellow, 1 in. or more in width; petals much longer than the sepals; achenia in globose heads, smooth, broadly margined, beak broad, straight or slightly curved. Quite variable in size and habit of growth, often producing flowers on erect stems before runners are formed. March–May. On rich, moist soil.

7. R. FASCICULARIS Muhl. TUFTED BUTTERCUP. Perennial, from a cluster of thickened, fleshy roots; stem erect, pubescent, 4–9 in. high; root leaves ternate, but the middle division long-stalked and 3–5-parted, making the leaf appear pinnate; stem leaves 3–5-parted or lobed, the divisions oblong or elliptical; flowers bright yellow, 1 in. broad; petals obovate, much longer than the sepals; achenia smooth, scarcely margined, beak slender, straight or slightly curved. March–May. On rich soil and rocky hills; more common northward.

XI. THALICTRUM.

Perennial herbs; leaves compound or decompound; flowers in umbels or panicles, polygamous or diœcious; sepals petal-like or greenish; petals none; achenia ribbed.

T. POLYGAMUM Muhl. MEADOW RUE. Stems from fibrous roots, tall and coarse, nearly or quite smooth, 4–8 ft. tall; leaves decompound, those of the stem sessile, the others long-petioled; leaflets oval or oblong, often cordate, smooth or pubescent beneath, quite variable in size on the same plant; flowers small, in large panicles; sepals 4 or 5, white; achenia short stalked. May–August. Woods and meadows.

XII. PÆONIA.

Perennial, from thick, fleshy roots; stems shrubby or herbaceous; leaves much divided; flowers terminal, large and showy; sepals 5, leaf-like and persistent; petals 5 or more; pistils 3–5, ovaries surrounded by a disk.

P. OFFICINALIS L. GARDEN PÆONY. Herbaceous; flowering stems 1–2 ft. high; leaves ample; leaflets lance-ovate, cut or incised, smooth; flowers double, white or red; follicles 2, erect, many-seeded. Common in gardens.

41. BERBERIDACEÆ. BARBERRY FAMILY.

Shrubs or herbs; leaves basal or alternate, simple or compound, exstipulate; flowers solitary or racemed, perfect, regular, hypogynous; sepals and petals in 2 or more rows of 2–4 each, deciduous; stamens usually as many as the petals and opposite them; pistil 1; fruit berry-like or capsular, many-seeded.

PODOPHYLLUM.

Perennial; stem simple, smooth, erect, 12–15 in. tall, bearing 2 leaves with a large white flower between them; sepals 6, caducous; petals 6–9, obovate; stamens twice as many as the petals; pistil 1, stigma large, flat, sessile; fruit berry-like, 1-celled, many-seeded.

P. PELTATUM L. MAY-APPLE. Rootstock rather large; leaves orbicular, peltate, 5–9-lobed and toothed, smooth, 9–12 in. wide; flowers 2 in. wide, on a peduncle 1–2 in. long; stamens prominent, anthers opening longitudinally; fruit 1½–2 in. long, oval, fragrant, edible; each seed surrounded by a pulpy aril. April–May. In rich woods. The roots and leaves are drastic, and are used in medicine.

42. MENISPERMACEÆ. MOONSEED FAMILY.

Herbaceous or woody climbing or twining vines; leaves alternate, palmately veined, entire or lobed, exstipulate, on slender petioles; flowers small, polygamous or diœcious, in axillary racemes or panicles; sepals 4–12; petals 6 or less; stamens usually 6; ovaries 3 or more, usually 6, 1-ovuled; fruit a drupe.

I. CEBATHA.

Woody vines; stems slender and very hard; leaves rather thick, ovate, entire or 3-lobed; flowers in axillary racemes or panicles, diœcious or polygamous; sepals 6; petals 6; fruit a drupe, with a rough, reniform seed.

C. Carolina (L.) Britt. Carolina Moonseed. Stem twining, slightly pubescent above, 10–15 ft. long; leaves 3-lobed, acute, rigid; pistillate flowers in simple, and the staminate in compound racemes, greenish-white, small; stamens 6; pistils 3–6; drupe bright red, globular or compressed, as large as a small pea. June–August. Borders of woods and thickets.

II. MENISPERMUM.

Vines slender, climbing, much like *Cebatha;* leaves 3–7-angled or lobed; flowers in axillary panicles, small, white; sepals and petals 4–8; stamens 12–24; pistils 2–4, stigmas dilated; fruit a drupe.

M. Canadense L. Moonseed. Stem twining, 8–12 ft. high; leaves 5–7-angled, slightly cordate, peltate near the base; flowers greenish-white; pistils in the fertile flowers on a prominent, raised receptacle; fruit globular, black; seed crescent-shaped. June–July. River banks; more common northward.

III. CALYCOCARPUM.

Stem twining, pubescent, 20–50 ft. high; leaves palmately 3–5-lobed; flowers diœcious, in compound racemes; sepals 6; petals none; stamens 12; pistils 3, stigmas radiate, spreading; drupe oval, seed shaped like a shallow cup.

C. Lyoni Nutt. Cupseed. Stem climbing to the tops of trees; leaves round-cordate, 6–8 in. wide, lobes acuminate, veins prominent; flowers whitish, in large, axillary clusters; drupe 1 in. long, greenish. June–July. River banks and moist woods.

43. CALYCANTHACEÆ. STRAWBERRY-SHRUB FAMILY.

Shrubs; leaves simple, opposite, entire, exstipulate; flowers perfect, solitary, terminal on lateral branches; sepals and petals alike, numerous, united below, forming an obconical, fleshy cup; stamens numerous, short, the inner ones usually sterile; ovaries several, inserted on the inner surface of the cup-shaped receptacle, becoming 1-seeded achenia in fruit.

BUTNERIA.

Shrubs, 4–8 ft. tall; branches opposite; leaves oval, pubescent beneath, short-petioled; both leaves and bark aromatic; sepals and petals many, in several rows, somewhat fleshy, indistinguishable; stamens numerous, short; pistils several, inserted on the inner side of the persistent calyx tube; mature fruit pear-shaped, dry, enclosing the achenia.

B. FLORIDA (L.) Kearney. SWEET-SCENTED SHRUB. A wide-spreading bush 4–8 ft. high; twigs pubescent; leaves oval or oblong, acute or acuminate, rough above, pubescent beneath, 2–3 in. long; flowers 1 in. wide, brownish-purple, very fragrant; sepals united below to form a cup on the inside of which the other parts of the flower are inserted, cup leafy-bracted on the outside. April–May. Banks of streams and rich hillsides; often cultivated.

44. LAURACEÆ. LAUREL FAMILY.

Aromatic trees or shrubs; leaves simple, alternate, exstipulate, dotted; flowers small, perfect or imperfect, in small, axillary clusters; calyx of 4–6 colored sepals in 2 rows; petals none; stamens 9–12, inserted on the calyx in 3–4 rows, distinct, usually some of them imperfect; ovary superior, style single, ovule solitary; fruit a drupe or berry. Among the foreign plants belonging to this family are the Cinnamon (*Cinnamomum Zeylandicum*) and Cassia (*C. cassia*) from Ceylon, and Camphor (*C. camphora*) from China and India. The latter is often planted for ornament in the Gulf States.

I. PERSEA.

Small trees or shrubs; leaves evergreen, coriaceous, entire, petiolate; flowers perfect, in axillary panicles; calyx 6-parted, persistent; stamens 12, in 4 rows, the inner sterile, anthers 4-celled; stigma disk-like; fruit an ovoid drupe.

P. BORBONICA (L.) Spreng. RED BAY. A shrub or small tree with dark brown bark; leaves lanceolate to oblong-ovate, dark green

and smooth above, paler and pubescent beneath, petioles $\frac{1}{2}$–1 in. long; peduncles about as long as the petioles; calyx pubescent, persistent, its lobes unequal; drupes dark blue, on thick, red pedicels. June–July. In moist woodlands.

II. SASSAFRAS.

A tree with rough, yellowish bark and a spreading top; leaves deciduous, entire or 2–3-lobed; flowers diœcious, involucrate, at the end of the twigs of the previous season; calyx 6-parted, persistent in the pistillate flowers; stamens 9, in 3 rows; pistillate flowers with 4–6 abortive stamens and a single ovary; fruit a drupe.

S. Sassafras (L.) Karst. Sassafras. A tree, usually small and slender, but sometimes with a trunk 3 ft. in diameter and 125 ft. high; leaves oval, entire, mitten-shaped or 3-lobed, pubescent when young but becoming smooth with age, dark green above, paler below, petiolate; racemes several in a cluster, peduncled; flowers yellow; stamens about as long as the sepals; fruit dark blue, ovoid, on thickened, red pedicels. All parts of the tree aromatic; trees producing pistillate flowers rare. April–May. Common. The wood is valuable for cabinet making, and an aromatic oil is extracted from the bark.

III. BENZOIN.

Shrubs; leaves deciduous, entire; flowers in lateral, sessile clusters, appearing before the leaves, diœcious or polygamous; involucre of 4 scales; stamens 9 in the staminate flowers, filaments slender; pistillate flowers with 12–15 abortive stamens and a single globose ovary with a short style.

B. Benzoin (L.) Coult. Spice-bush. A shrub 5–15 ft. high, with smooth bark and slender twigs; leaves oblong-obovate, acute at the base, pale and pubescent beneath, becoming smooth when old; petioles short; flowers about as long as the pedicels, yellow, very fragrant; ovary about as long as the style; fruit an obovoid, red drupe about $\frac{1}{3}$ in. long, on a slender pedicel. February–March. Banks of streams and damp woods. Twigs and leaves quite aromatic.

45. PAPAVERACEÆ. POPPY FAMILY.

Herbs, with milky or colored juice; leaves alternate, or rarely a few of the upper ones opposite, exstipulate; flowers perfect, solitary or in clusters; sepals 2–3, caducous; petals 4–12, deciduous, sometimes irregular; stamens few or many, hypogynous, filaments filiform; ovaries 1 or many, usually 1-celled, many-seeded; fruit a capsule.

I. PAPAVER.

Annual or perennial herbs, with milky juice; stem erect, smooth or hispid, branching above; leaves more or less lobed or dissected; flower buds nodding, flowers showy; sepals commonly 2; petals 4–6; stamens many; stigma disk-like, ovules many, borne on inwardly projecting placentæ.

1. P. SOMNIFERUM L. OPIUM POPPY. Annual; stem erect, branched above, smooth and glaucous, 2–3 ft. high; leaves oblong, irregularly lobed or cut, sessile, clasping; flowers nearly white with a purple center, large and showy, on long peduncles; capsule globose, seeds minutely pitted. May–August. About old gardens and waste places. Cultivated in southern Asia, where the juice of the capsules is dried to make opium.

2. P. DUBIUM L. CORN POPPY. Annual; stem slender, branching, 1–2 ft. tall; leaves pinnatifid, the lower petioled, the upper sessile; flowers large and showy, usually red; capsule long-obovate, glabrous. May–July. In cultivated ground. Both the species named are often cultivated in gardens, and produce double flowers.

II. SANGUINARIA.

Perennial; rhizome thick, horizontal, joints and scars of previous growths persistent several years; juice orange colored; leaves on long petioles, reniform; scape 1-flowered; sepals 2, fugacious; petals 8–12; ovary 1, stigmas 2; capsule oblong, seeds crested.

S. CANADENSIS L. BLOODROOT. Leaves and scape glaucous; leaves palmately 5–9-lobed, lobes rounded or toothed; scapes naked,

nearly as long as the petioles; flowers white, 1 in. or more wide; petals oblong or obovate, quickly deciduous; capsule 1-celled, 2-valved, the valves separating from the persistent placentæ at maturity. March–April. In rich, shady woods.

III. CAPNOIDES.

Erect herbs; juice reddish-brown; leaves much dissected or decompound; flowers in racemes which are terminal or opposite the leaves; sepals 2, small; corolla irregular, petals 4, one of the outer spurred or saccate at the base, the 2 inner narrower and keeled on the back; stamens 6, three opposite each of the outer petals; stigma 2-lobed, persistent; placentæ 2.

C. MICRANTHUM (Engelm.) Britt. DUTCHMAN'S BREECHES. Stem slender, diffuse, glabrous; leaves finely dissected, the divisions nearly linear; flowers pale yellow; outer petals unmargined, the keel usually entire; fruit a linear, torulose, short-pedicelled pod. February–March. In rich woods.

44. CRUCIFERÆ. MUSTARD FAMILY.

Herbs, with watery, pungent juice; leaves alternate, exstipulate; flowers perfect, regular, hypogynous, in racemes or panicles with bractless pedicels; sepals 4, usually erect and appressed to the corolla, deciduous; petals 4, with spreading limbs forming a cross, rarely wanting; stamens usually 6, two of them shorter than the others and opposite the inner sepals; pistil 1, compound, style usually persistent, ovary 2-celled by a membranous partition; fruit a silique or silicle. The family furnishes a number of food plants, among which are the cabbage, cauliflower, brussels sprouts, kohl rabi, and kale, all of which are forms of the European *Brassica oleracea*; the Turnip (*B. campestris*) and the Horse Radish (*Roripa Armoracia*) which does not produce seed in this country. Most of the native plants belonging to the family are insignificant or troublesome weeds.

Pod many times longer than broad.
  Flowers yellow . . . . . . V. Sophia.
  Flowers white or colored.
    Seeds globose . . . . . VII. Hesperis.
    Seeds flat . . . . . . III. Cardamine.
Pod short.
  Flat, orbicular.
    Flattened contrary to the partition I. Lepidium.
    Flattened parallel to the partition . VI. Koniga.
  Flat, cuneiform . . . . . . IV. Bursa.
  Terete, globose or oblong . . . . II. Roripa.

I. LEPIDIUM.

Annual; stem erect, or sometimes diffuse; leaves entire, toothed or pinnately divided; flowers in a terminal raceme, small, white; petals short, sometimes wanting; stamens 2, 4, or 6; silicle rounded or obcordate, flattened contrary to the partition.

L. Virginicum L. Peppergrass. Stem erect, smooth, much branched, 1–2 ft. high: lower leaves obovate in outline, pinnatifid with dentate lobes; upper leaves lanceolate, dentate, slightly pubescent; flowers on slender pedicels, petals often wanting in the later ones; stamens 2; silicle orbicular. March–July. A weed growing in waste places.

II. RORIPA.

Annual or biennial; stems erect or diffuse, often widely branching; leaves simple, pinnately lobed; flowers small, white or yellow; sepals spreading; stamens 1–6; silique short and broad or nearly linear; seeds numerous, in 2 rows in each cell.

1. R. Nasturtium (L.) Rusby. Watercress. Aquatic herbs; stems glabrous, diffuse, rooting at the joints; leaves with 3–9 rounded, pinnate lobes, the terminal lobe much the largest; racemes elongating in fruit; petals white, twice the length of the sepals; pod linear, $\frac{1}{2}$–$\frac{3}{4}$ in. long, on slender, spreading pedicels. March–November. In ditches and slow streams. Often used for salad.

2. R. palustris (L.) Bess. Yellow Watercress. Annual or biennial; stem erect, branched, slightly pubescent; leaves irregu-

larly lyrate-pinnatifid, the lower petioled, the upper sessile; flowers small; petals yellow; pods linear, spreading, longer than the pedicels. March–April. In wet places.

III. CARDAMINE.

Annual or perennial; rootstock often scaly or bulbiferous; stem erect or ascending, usually glabrous; leaves more or less divided; flowers in terminal racemes, white or purple; petals rather large; stamens 6; fruit an elongated silique, seeds several in a single row in each cell.

C. BULBOSA (Schreb.) B. S. P. BULBOUS CRESS. Perennial; root tuberous; stem simple, erect, smooth, without runners, 9–18 in. tall; lower leaves long-petioled, ovate, orbicular or cordate, often angled or toothed, the upper short-petioled or sessile, lanceolate or oblong, toothed or entire; pedicels $\frac{1}{2}$–1 in. long; petals white, $\frac{1}{4}$–$\frac{1}{3}$ in. long; silique erect, linear-lanceolate, tipped by the persistent style; seeds round-oval. April–May. Cool, wet places.

C. HIRSUTA L. HAIRY BITTERCRESS. Annual; stem slender, erect, simple or with a few slender branches, more or less pubescent, 6–15 in. tall; leaves mostly in a cluster at the base of the stem, pinnately divided, the terminal lobe orbicular, the lateral lobes narrower, somewhat hirsute above, stem leaves nearly linear; flowers small; petals white, longer than the sepals; stamens 4; pods linear, erect on erect pedicels, about 1 in. long; seeds oval. March–April. In waste places.

IV. BURSA.

Annual; stem erect; pubescence of branched hairs; racemes terminal, becoming elongated in fruit; flowers small, white; silicle obcordate or triangular, flattened contrary to the partition, shorter than the spreading pedicel.

B. BURSA-PASTORIS (L.) Britt. SHEPHERD'S PURSE. Root long and straight; stem branching above, pubescent below, smooth above; lower leaves forming a rosette at the base of the stem, irregularly lobed or pinnatifid, stem leaves lanceolate, clasping, toothed or entire; sepals pubescent, about half as long as the petals; pod triangular, emarginate or cordate at the apex; seeds several in each cell. February–July. A common weed.

V. SOPHIA.

Annual or perennial; stem erect, slender, branching, pubescent; leaves twice pinnatifid or dissected; flowers in terminal racemes, small, yellow, racemes becoming elongated at maturity; silique linear or linear-oblong, terete or angled, seeds oval, in 1 or 2 rows in each cell.

S. PINNATA (Walt.) Britt. HEDGE MUSTARD. Annual; stem erect, branched, pale canescent or hoary, 12–24 in. tall; leaves oblong, twice pinnatifid into narrow, toothed segments; pedicels slender, spreading, about ½ in. long; flowers small, pale; silique horizontal or ascending, about half the length of the pedicel, seeds in 2 rows in each cell. March–April. Common in waste places.

VI. KONIGA.

Perennial, though usually growing as an annual; stems branching, diffuse, branches slender; leaves small, entire, pubescent with forked hairs; flowers small, white, in numerous terminal racemes; petals obovate, entire, twice as long as the sepals; filaments enlarged below; silicle orbicular, compressed, seeds 1 in each cell.

K. MARITIMA (L.) R. Br. SWEET ALYSSUM. Stem weak, diffuse, ascending, minutely pubescent; lower leaves narrowed into a petiole, the upper sessile; racemes erect, many-flowered; flowers fragrant, pedicels ascending; silicle often pointed. Common in cultivation and often spontaneous.

VII. HESPERIS.

Biennial or perennial; stems erect, branched, pubescent with forked hairs; leaves seldom divided; flowers showy, in terminal racemes; stigma 2-lobed; fruit a long, cylindrical silique.

H. MATRONALIS L. DAME'S VIOLET. Stem branched above, 2–3 ft. high; leaves lanceolate or ovate-lanceolate, acute or acuminate, denticulate with minute teeth, pubescent on both sides, the lower long-petioled and sometimes divided, the upper short-petioled or sessile; flowers white or colored, fragrant, ¾–1 in. wide; petals

spreading, much longer than the erect sepals; silique slender, nodulose, 2–4 in. long; seeds 1 row in each cell. March–July. Escaped from cultivation.

47. CAPPARIDACEÆ. CAPER FAMILY.

Herbs, shrubs or trees, with an acrid, watery juice; leaves usually alternate, simple or palmately compound; stipules spiny or wanting; flowers often irregular, usually perfect; sepals 4–8; petals 4 or wanting; stamens 6 or more; style usually short, receptacle often elongated; fruit a pod or berry.

CLEOME.

Mostly annual herbs; stems branched; leaves petioled, simple or 3–7-foliate, leaflets entire or serrate; flowers in bracted racemes; sepals 4, often persistent; petals 4, long-clawed, nearly equal, entire; stamens 6, filaments filiform, usually much exserted but sometimes 1–3 much shorter than the others, inserted on the short receptacle; ovary on a short stipe with a small gland at its base; fruit a slender capsule on an elongated stipe.

C. SPINOSA L. SPIDER FLOWER. Annual; stem erect, branched above; leaves alternate, large, the lower long-petioled, the upper short-petioled or sessile, 5–7-foliate, leaflets lanceolate, acute, serrulate; stipules spiny; flowers numerous, showy, white or purplish, in long, bracted racemes, lower bracts trifoliate, the upper simple, cordate-ovate; pedicels long; petals obovate, long-clawed; capsule smooth, linear, shorter than the stipe which is often 4–6 in. in length. May–August. Common in waste places.

48. RESEDACEÆ. MIGNONETTE FAMILY.

Annual; stem diffuse, widely branched; leaves sessile, entire or lobed, smooth; flowers in spikes or racemes, bracted, irregular, fragrant; calyx 4–7-parted, inequilateral; petals 4–7, entire or cleft; stamens 8–30, inserted on the hypogynous, one-sided disk; ovary sessile, 3–6-lobed, stigmas 3–6, ovules many.

RESEDA.

Annual; stems diffuse, widely branched; leaves sessile, entire or lobed, smooth; flowers in close racemes or spikes; petals 4–7, toothed or cleft; stamens 8–30, inserted at one side of the flower; capsule 3–6-lobed, opening at the top before the seeds mature.

R. ODORATA L. MIGNONETTE. Stem widely diffuse, 6–12 in. high, smooth; leaves cuneiform, entire or 3-lobed; flowers small, greenish-yellow, very fragrant; petals deeply 7–13-cleft. April–July. Often cultivated. From Egypt.

49. SARRACENIACEÆ. PITCHER-PLANT FAMILY.

Perennial, acaulescent, marsh herbs; leaves tubular or trumpet-shaped; flowers single, nodding, on a naked or bracted scape; sepals 4–5, colored, persistent; petals 5, deciduous, or sometimes wanting; stamens numerous; pistil compound, 5-celled, many-ovuled, style terminal, nearly as broad as the flower, peltate.

SARRACENIA.

Rootstock short, horizontal; scape naked; leaves trumpet-shaped with a ventral wing extending nearly to the base and a broad lamina at the apex; tube hairy within, with downward-pointing, stiff hairs; calyx 3-bracted; petals obovate, drooping or incurved; style umbrella-shaped, 5-angled; stigmas at the hooked angles of the style; capsule globose, rough. [The tubular leaves usually contain more or less water and dead insects, the latter having been attracted by a honey-like secretion near the opening. For a full account of the structure and peculiar action of the leaves, see Goodale's *Physiological Botany*, pp. 347–353.]

1. S. PURPUREA L. SIDE-SADDLE FLOWER. Leaves ascending, curved, broadly winged, purple-veined, 4–8 in. long; lamina erect, round-cordate, hairy on the inner side; scapes 12–18 in. tall; flower deep purple, about 2 in. broad; style yellowish. April–May. Mossy swamps.

2. S. PSITTICINA Michx. SMALL PITCHER-PLANT. Leaves in a spreading rosette, 3–5 in. long; tube slender, broadly winged, densely hirsute within; lamina strongly incurved over the narrow opening, marked with purple and white; flower purple, about $1\frac{1}{2}$ in. broad. April–May. Pine-barren swamps.

3. S. FLAVA L. TRUMPET-LEAF. Leaves large, erect, glabrous, yellowish, narrowly winged, 2 ft. high; lamina erect, orbicular, slender pointed, pubescent within, often reticulated with purple veins; scape as long as the leaves; flowers yellowish; petals 2–3 in. long, finally drooping. April–May. Wet pine barrens.

4. S. VARIOLARIS Michx. SPOTTED TRUMPET-LEAF. Leaves erect, broadly or sometimes narrowly winged, spotted with white near the yellowish summit; lamina ovate, arching over the open mouth of the tube, hairy, and reticulated with purple veins within; flowers yellow; petals 1 in. or more in length. April–May. Low pine barrens.

50. DROSERACEÆ. SUNDEW FAMILY.

Acaulescent, marsh herbs; leaves tufted, glandular-pubescent, circinate in bud; flowers racemose, on a slender, naked scape; calyx of 4–5 distinct or slightly united, persistent sepals; petals 5, distinct or slightly united at the base, hypogynous, withering; stamens 5–15, distinct; ovary free, 1-celled, many-ovuled, styles 1–5, simple or cleft.

DROSERA.

Leaves thickly set with glandular hairs, making them appear as if covered with dew; calyx free from the ovary, deeply 4–5-parted; petals usually 5; stamens 5; styles 3–5, deeply 2-parted or fimbriate; capsule 3-valved, many-seeded.

1. D. FILIFORMIS Raf. THREAD-LEAVED SUNDEW. Rhizome thick, creeping; leaves erect, narrowly linear or filiform, smooth at the base, very viscid-pubescent above, 10–15 in. long; scape smooth, many-flowered, 12–18 in. high; flowers bright purple, 1 in. wide; petals obovate, much longer than the hairy sepals; seeds oblong, minutely dotted. April–May. Low pine barrens.

2. D. ROTUNDIFOLIA L. ROUND-LEAVED SUNDEW. Rhizome none; leaves orbicular, contracted below into a hairy petiole $1\frac{1}{2}$–2 in. long; scape smooth, erect, 6–10-flowered; flowers white; seeds covered with a loose, membranaceous coat. May–June. Mossy swamps.

3. D. BREVIFOLIA Pursh. SHORT-LEAVED SUNDEW. Rhizome none; leaves short, wedge-shaped, glandular-pubescent; scape 3–6-flowered, 3–6 in. high; flowers white, ½ in. wide; seeds ovoid, minutely glandular. March–April. Low, sandy pine barrens.

51. CRASSULACEÆ. ORPINE FAMILY.

Herbs, usually succulent; leaves alternate or opposite, simple, exstipulate; flowers perfect, regular, cymose or rarely solitary; calyx 4–5-cleft, persistent; petals as many as the sepals, often slightly united at the base, usually persistent, sometimes wanting; stamens as many or twice as many as the petals; carpels as many as the petals, distinct, or united below; fruit a membranaceous, 1-celled, many-seeded follicle.

PENTHORUM.

Perennial; stem erect, branched above, only slightly succulent; leaves alternate, serrate, sessile; flowers in cymes; sepals 5; petals 5 or wanting; stamens 10; carpels 5, united about half their length, many-seeded.

P. SEDOIDES L. DITCH STONECROP. Stem terete below, branching and angled above, glabrous, 1–2 ft. high; leaves lanceolate or elliptical, acuminate, finely serrate; flowers yellowish, short-pediceled, on one side of the revolute branches of the cyme; sepals triangular, acute, shorter than the capsule; petals often wanting. June–September. Common in ditches and muddy places.

52. SAXIFRAGACEÆ. SAXIFRAGE FAMILY.

Herbs, shrubs, vines or trees; leaves alternate, opposite or basal; stipules adnate to the petioles or wanting; flowers perfect or imperfect, solitary or variously clustered; calyx of 4–5 more or less united sepals, free or partially adherent to the ovary; petals as many as the sepals or sometimes wanting; stamens as many or twice as many as the sepals, inserted on the calyx; ovaries 1–4, commonly united below and often separated above; fruit a capsule or berry.

I. PARNASSIA.

Perennial herbs; basal leaves long-petioled, entire; the slender scape bearing a single, sessile leaf; flowers large, solitary; sepals 5, persistent, united at the base; petals 5, spreading; fertile stamens 5, alternate with the petals; abortive stamens numerous, in clusters at the base of each petal; ovary 1-celled, with 3–4 parietal placentæ; seeds numerous.

P. CAROLINIANA Michx. GRASS-OF-PARNASSUS. Basal leaves ovate or cordate, rounded at the apex, often decurrent into the petioles; cauline leaf ovate, clasping; scape 12–18 in. high; flower $1-1\frac{1}{2}$ in. broad; sepals ovate; petals oval, white with greenish veins; abortive stamens 3 in each set, distinct, much longer than the recurved fertile ones; capsule $\frac{1}{3}-\frac{1}{2}$ in. long. June–October. On damp soil.

II. ITEA.

Shrubs or small trees; leaves alternate, simple, deciduous, exstipulate; flowers white, in slender, drooping, terminal racemes; calyx campanulate, 5-cleft; petals 5, inflexed at the apex; stamens 5, shorter than the petals; ovary 2-celled, many-seeded.

I. VIRGINICA L. ITEA. A shrub, 4–10 ft. high; twigs pubescent; leaves oblong or oval, short-petioled, acute or acuminate at the apex, sharply serrate, glabrous or somewhat pubescent beneath; racemes slender, dense, 3–6 in. long; flowers short-pediceled, white, $\frac{1}{3}-\frac{1}{2}$ in. wide; petals narrowly lanceolate, erect or spreading; capsule 2-grooved, pubescent, tipped by the persistent, 2-parted style. April–June. Common in wet places.

III. HYDRANGEA.

Erect shrubs; leaves simple, opposite, petioled, exstipulate; flowers in terminal corymbs, marginal flowers often sterile with enlarged and showy calyx lobes, fertile flowers small; calyx tube hemispherical, 8–10-ribbed, coherent with the ovary, limb 4–5-cleft; petals 4–5; stamens 8–10; capsule 2–4-celled, crowned with the divergent styles, many-seeded.

1. H. RADIATA Walt. DOWNY HYDRANGEA. Shrub, 6–8 ft. tall; leaves ovate, often cordate at the base, acute or acuminate at

the apex, serrate, smooth above, densely white-tomentose beneath; cymes flat-topped; sterile flowers few, but large and conspicuous. May–June. On rich soil, river banks, etc.

2. H. QUERCIFOLIA Bart. OAK-LEAFED HYDRANGEA. Shrub, 3–6 ft. tall; leaves oval, usually 5-lobed, serrate, tomentose; cymes clustered in a dense, oblong panicle; sterile flowers large and numerous, whitish, becoming purple. May–June. On shady banks.

3. H. HORTENSIS L. GARDEN HYDRANGEA. Shrub 1–3 ft. tall; leaves elliptical, acute at each end, serrate-dentate, smooth, strongly veined; cymes convex above; flowers nearly all sterile, white, blue, or pink. May–July. Common in gardens.

IV. PHILADELPHUS.

Shrubs; leaves simple, opposite, 3–5-ribbed, petioled, exstipulate; flowers solitary or cymose, large, white; calyx tube turbinate, cohering with the ovary, the limb 4–5-parted, persistent; petals 4–5, rounded or obovate; stamens 20–40, shorter than the petals; ovary 3–5-celled, many-seeded, styles 3–5, more or less united.

1. P. GRANDIFLORUS Willd. LARGE-FLOWERED SYRINGA. Shrub, 6–10 ft. high; branches pubescent; leaves ovate or ovate-oblong, acuminate, sharply serrate, pubescent, 3-ribbed; flowers solitary or 2–3 together, white, 1½–2 in. broad, not fragrant; calyx lobes ovate, acuminate, about twice as long as the tube. April–May. On low ground.

2. P. CORONARIUS L. GARDEN SYRINGA. Shrub, 8–10 ft. high; leaves oval or ovate, obtuse at the base, acute at the apex, remotely denticulate, smooth above, pubescent beneath; flowers in terminal racemes, creamy white, 1–1½ in. wide, very fragrant; calyx lobes ovate, acute, longer than the tube. May–June. Common in cultivation.

53. GROSSULARIACEÆ. GOOSEBERRY FAMILY.

Shrubs; branches smooth or prickly; leaves alternate, often fascicled, palmately veined and lobed; stipules wanting; flowers axillary, racemose or clustered; calyx tube adherent to the ovary, limb 5-parted, persistent; petals 5, small; stamens 5; ovary 1-celled, with 2 parietal placentæ; fruit a many-seeded berry.

RIBES.

Characters of the family.

1. R. Cynosbati L. Wild Gooseberry. A spreading bush 2–4 ft. tall, with the older stems prickly and the younger nearly smooth; leaves nearly circular, slightly cordate, 3–5-lobed, the lobes crenate or incised, somewhat pubescent, petiole long and slender; peduncles 2–3-flowered, flowers greenish; stamens and style not longer than the calyx tube; berry covered with prickles. April–June. In rocky woods. More common northward.

2. R. rotundifolium Michx. Smooth Gooseberry. A straggling shrub 3–4 ft. high, the branches often smooth; leaves roundish, the base not cordate and often acute, 3–5-lobed and incised, pubescent beneath; peduncles 1–2-flowered, flowers greenish-purple; stamens longer than the calyx tube; berry small, smooth. April–June. In rocky woods.

3. R. rubrum L. Red Currant. A shrub 2–4 ft. high, branches smooth; leaves orbicular to reniform, 3–5-lobed, the lobes sharply dentate, pubescent beneath when young; petioles slender, 1–3 in. long; flowers many, in pendulous racemes, greenish, pedicels bracted; stamens short; fruit smooth, red or nearly white. April–May. Native in the northern states and often cultivated.

54. HAMAMELIDACEÆ. WITCH-HAZEL FAMILY.

Trees or shrubs, with alternate, petioled, simple leaves and deciduous stipules; flowers perfect, polygamous or monœcious, variously clustered; calyx tube coherent with the base of the ovary; petals 4–5, long and showy, or entirely wanting; stamens twice as many as the petals with the alternate ones sterile, or numerous and perfect; styles 2; fruit a woody, 2-celled capsule opening at the summit, seeds bony, 1 or more in each cell.

I. HAMAMELIS.

Large shrubs; leaves short-petioled; flowers yellow, lateral, clustered; calyx 2–3-bracted, 4-parted; petals 4, elongated and linear, sometimes wanting in the staminate flowers; stamens 8, the alternate ones sterile; styles 2, ovules 2; seeds large, bony, oblong, shiny.

H. VIRGINICA L. WITCH HAZEL. A shrub sometimes reaching 20 ft. in height; leaves obovate or oval, acute or obtuse at the apex, cordate or oblique at the base, dentate, stellate-pubescent; flowers in axillary clusters, bright yellow, nearly sessile; calyx lobes spreading, pubescent; petals $\frac{1}{2}$-$\frac{3}{4}$ in. long; capsule woody, beaked by the 2 persistent styles, very pubescent. October and November, the fruit requiring nearly a year to mature. Common in low woods and on margins of swamps.

II. LIQUIDAMBAR.

Trees, the limbs usually corky-winged; flowers monœcious, the staminate heads sessile, spiked or racemose, the pistillate usually single; calyx and corolla wanting; stamens very numerous, filaments short; ovary partly inferior, styles 2, ovules several in each cell; the 2-beaked capsules united into a close head, seeds wing-angled.

L. STYRACIFLUA L. SWEET-GUM. Large trees; leaves roundish, stellate-lobed, finely serrate, smooth above, often pubescent below; spikes bearing the staminate flowers soon deciduous; the pistillate heads long-peduncled, soon drooping, mature heads spiny, 1–1$\frac{1}{2}$ in. in diameter. March April. A common tree with a resinous juice which hardens into a fragrant gum.

55. PLATANACEÆ. SYCAMORE FAMILY.

Trees; with simple, alternate, petioled, stipulate leaves, the bases of the petioles covering the buds; flowers monœcious, in axillary, long-peduncled, globose heads; calyx and corolla very inconspicuous, each consisting of 3 8 minute scales, or wanting; stamens as many as the sepals and opposite them; pistils several, obconical, hairy at the base, styles long; capsules 1-seeded.

PLATANUS.

Characters of the family.

P. OCCIDENTALIS L. SYCAMORE, BUTTONWOOD. A large tree, bark light-colored, smooth, exfoliating in large, thin plates; leaves large, round-cordate, angularly lobed and toothed, densely white-woolly when young, becoming smooth with age; stipules large,

toothed; fruit in a globular, pendulous head which remains on the tree through the winter, dropping the seeds very slowly. March–April. Common on river banks and in swampy woods.

56. ROSACEÆ. ROSE FAMILY.

Herbs, shrubs or trees; leaves alternate, simple or compound, stipulate; flowers perfect; sepals 3–8, usually 5, more or less united; petals as many as the sepals or none; stamens numerous and, with the petals, inserted on the calyx tube; pistils 1, few or numerous, often united with the calyx tube; ovary 1-2- or several-seeded; fruit of many forms, but more often an achene, follicle, or aggregation of drupes.

Fruit a follicle.	
Follicles inflated	I. Opulaster.
Follicles not inflated.	
Flowers regular	II. Spirea.
Flowers irregular	III. Porteranthus.
Fruit an aggregation of drupes	IV. Rubus.
Fruit an achene.	
Achenes many.	
Receptacles fleshy, flowers white . .	V. Fragaria.
Receptacles fleshy, flowers yellow .	VI. Duchesnea.
Receptacles dry, styles deciduous .	VII. Potentilla.
Receptacles dry, styles persistent .	VIII. Geum.
Achenes 1 or 2	IX. Agrimonia.
Achenes enclosed by the fleshy calyx tube .	X. Rosa.

I. OPULASTER.

Shrubs; leaves simple, palmately veined and lobed, petioled; flowers white, in terminal corymbs; calyx spreading, 5-lobed; petals 5; stamens numerous; pistils 1–5, short-stipitate, stigma terminal; ovaries becoming inflated at maturity, 2–4-seeded, dehiscent.

O. OPULIFOLIUS (L.) Kuntze. NINEBARK. A spreading shrub 3–6 ft. high, the old bark separating into thin strips; leaves petioled, broadly ovate or rounded, often cordate, 3-lobed, the lobes doubly

crenate-serrate; stipules deciduous; corymbs terminal, peduncled, nearly globose, pubescent, many-flowered; pedicels and calyx nearly glabrous; follicles 3–5, much longer than the calyx, smooth and shining, obliquely tipped by the persistent style. April–May. Banks of streams.

II. SPIREA.

Shrubs with simple leaves; flowers perfect, in terminal or axillary racemes or panicles; calyx 5-cleft, persistent; petals 5; stamens numerous; pistils usually 5, free from the calyx and alternate with its lobes; follicles not inflated, 2–several-seeded.

1. S. SALICIFOLIA L. WILLOW-LEAFED SPIREA. Shrubs 2–5 ft. high, branches smooth; leaves lanceolate to oblong-ovate, smooth or nearly so, sharply serrate, base usually cuneate, pale beneath; stipules deciduous; flowers white or pink, panicle dense-flowered; follicles smooth. May–July. On low ground.

2. S. REEVESIANA Gard. BRIDAL WREATH. Shrubs 2–4 ft. tall; branches long, slender and spreading; leaves lanceolate, serrate, sometimes 3-lobed or pinnatifid, glaucous beneath; flowers white or pinkish, in axillary racemes or corymbs, often forming long wreaths; follicles smooth. May–June. Introduced from Europe.

3. S. TOMENTOSA L. HARDHACK. Erect shrubs; stems tomentose, usually simple; leaves simple, ovate or oblong, serrate, densely tomentose below, smooth and dark green above; flowers small, pink or purple, in a close panicle; follicles 5, tomentose, several-seeded. May–June. On low ground.

III. PORTERANTHUS.

Perennial herbs; leaves nearly sessile, 3-foliate or 3-parted; flowers white or rose-colored, in loose corymbs; calyx tubular-campanulate, 5-toothed; petals 5, unequal; stamens 10–20; follicles 5, included in the calyx, 2–4-seeded.

P. STIPULATUS (Muhl.) Britt. AMERICAN IPECAC. Stem 2–3 ft. tall, branches few; leaves lanceolate, coarsely serrate or the lower incisely lobed; stipules leaf-like, ovate, serrate; corymbs few-flowered, flowers pink; petals linear-lanceolate, $\frac{1}{2}$ in. long; follicles nearly smooth. May–June. On hills in rich woods.

IV. RUBUS.

Shrubs; stems usually prickly; leaves ample, 3–5-lobed or compound; calyx bractless, concave or nearly flat, 5-parted; petals 5; stamens numerous; pistils numerous, forming small drupelets which are inserted on an elongated receptacle to form an aggregated fruit, style deciduous.

1. R. OCCIDENTALIS L. BLACK RASPBERRY. Stems long and slender, often recurved and rooting at the tips, armed with weak, hooked prickles; leaves petioled, 3–5-foliate, leaflets ovate, coarsely serrate, white-downy below; flowers white, in compact terminal corymbs; pedicels erect or ascending; fruit black, hemispherical, separating easily from the receptacle. April–May. Common on borders of woods northward, widely cultivated.

2. R. STRIGOSUS Michx. RED RASPBERRY. Stems widely branching, biennial, not rooting at the tips, armed with weak bristles and with a few hooked prickles; leaves petioled, 3–5-foliate; leaflets ovate, acuminate, sharply serrate and sometimes lobed, pubescent beneath; flowers in terminal and axillary racemes and panicles, pedicels drooping; fruit hemispherical or conical, red, separating easily from the receptacle. April–May. Common on mountains and burned clearings in the northern section and widely cultivated.

3. R. ARGUTUS Bailey. BLACKBERRY. Stem shrubby, erect or bending, 4–10 ft. high, glandular-pubescent above and with stout, hooked prickles below; leaves petioled, 3–7-foliate, leaflets ovate, acute, irregularly serrate, smooth or soft hairy; flowers in terminal, bracted panicles; petals white, obovate, much longer than the acuminate sepals; fruit large, black, oblong, adhering to the receptacle. March–May. Common in thickets.

4. R. CUNEIFOLIUS Pursh. SAND BLACKBERRY. Stem shrubby, erect or diffuse, 2–3 ft. high; prickles straight or recurved; leaves petioled, 3–5-foliate, leaflets obovate, serrate towards the apex, cuneate towards the base, rough above, white tomentose beneath; racemes mainly terminal, few-flowered; petals white, longer than the sepals; fruit ovoid, black, adhering to the receptacle, smaller than the preceding. March–April. Common in old fields.

5. R. TRIVIALIS Michx. DEWBERRY. Stem trailing or prostrate, often several feet in length, armed with small, straight or recurved prickles, and often thickly set with bristles; leaves petioled, mostly 3-foliate; leaflets ovate-lanceolate or oval, acute, sharply serrate, smooth; flowering branches commonly erect, few-flowered, flowers large, white; fruit black, adhering to the receptacle. March–April. Common on dry, sandy soil.

V. FRAGARIA.

Perennial herbs; acaulescent, producing new plants at the ends of long runners; leaves trifoliate, long-petioled; flowers in long-peduncled cymes; calyx 5-bracted, persistent, 5-parted; petals 5; stamens many; pistils many, forming achenes which are inserted on a fleshy receptacle.

1. F. VIRGINIANA. Duchesne. WILD STRAWBERRY. Leaflets thick, oval to obovate, coarsely serrate, somewhat hairy; scape usually shorter than the petioles, few-flowered; fruit ovoid, achenes imbedded in deep pits. March–May. Common.

2. F. VESCA L. EUROPEAN STRAWBERRY. Leaflets ovate or broadly oval, dentate above, cuneate below, slightly hairy; scape usually longer than the petioles; fruit globular or oval, achenes adherent to the nearly even surface of the receptacle. March–May. Common in cultivation. Many of the cultivated varieties of strawberry are hybrids between the two described above.

VI. DUCHESNEA.

Perennial herbs; acaulescent, spreading and multiplying by leafy runners; leaves trifoliate; flowers axillary, long-peduncled; calyx 5-bracted, 5-parted; petals 5; stamens numerous; pistils numerous; achenes numerous on an enlarged receptacle.

D. INDICA (Andr.) Focke. STRAWBERRY GERANIUM. Leaflets oval or round-obovate, crenate, obtuse at the apex; peduncles 1-flowered; petals yellow; fruit insipid. April–June. In waste places, escaped from cultivation.

VII. POTENTILLA.

Herbs or shrubs; leaves palmately or pinnately compound; flowers perfect, solitary or cymose; calyx persistent, 5-bracted, 5-cleft; petals 5, obcordate; stamens numerous; carpels numerous, inserted on a dry, pubescent receptacle, style terminal or lateral, deciduous.

P. CANADENSIS L. CINQUEFOIL. Perennial herbs; stem simple, trailing or ascending, 2–3 ft. long; leaves palmately 5-foliate;

leaflets oval or oblong, serrate toward the apex, entire below; flowers yellow, solitary, on long axillary peduncles; petals oval, a little longer than the sepals; style terminal. June–August. In dry meadows.

VIII. GEUM.

Perennial herbs; leaves pinnately divided; flowers solitary or in cymose clusters; calyx persistent, 5-bracted, 5-lobed; petals 5; stamens and achenes numerous; styles long, straight and smooth, or jointed and hairy.

G. Canadense Jacq. White Avens. Stem erect, branching above, smooth or finely pubescent, 18–24 in. high; radical leaves pinnate, or the earliest simple and rounded, long-petioled, serrate or dentate, terminal lobe larger than the lateral lobes; stem leaves short-petioled, 2–5-lobed or parted; flowers on slender peduncles; petals white, not longer than the sepals; styles jointed near the middle, the lower portion persistent and hooked; ovaries and receptacle hairy, head of fruit globose. April–May. Rich woods.

IX. AGRIMONIA.

Perennial herbs; stem erect; leaves unequally pinnate, stipules leafy; flowers small, yellow, in spicate racemes; calyx tube obconic, 5-cleft, covered with hooked bristles; petals 5, small; stamens 5–15; achenes 2, included in the calyx tube, fruit drooping.

A. parviflora Sol. Agrimony. Stem branched, hirsute, 3–6 ft. high; leaves very numerous; leaflets 9–15, about 1 in. long, lanceolate or oblong, serrate, roughish above, pubescent below, glandular; small leaf-segments often alternating with the leaflets; flowers numerous, in long spike-like racemes, small, yellow; mature fruit reflexed, glandular-bristly. July–August. On dry ground.

X. ROSA.

Shrubs; stems erect, sometimes climbing, armed with prickles; leaves pinnately compound, stipules adnate to the petioles; calyx 5-cleft, the tube urn-shaped, becoming fleshy in fruit; petals 5, spreading; stamens and pistils numerous, carpels many, usually pubescent, inserted on the receptacle which covers the inner side of the calyx tube; achenes bony.

[Most of the cultivated roses have many of the stamens transformed into petals, forming what are known as double flowers. A large portion of those commonly found in gardens are hybrids of several Asiatic species.]

1. R. SETIGERA Michx. CLIMBING ROSE. Stem long, climbing or reclining, somewhat prickly but not bristly; leaflets 3–5, ovate, acute, sharply serrate, smooth and shining above, stipules narrow; petioles and peduncles somewhat glandular-pubescent; flowers in terminal corymbs, red or pink, 2–3 in. wide; calyx glandular, sepals finally deciduous; styles cohering in a column; fruit globose, smooth or slightly glandular. May–June. Borders of swamps. Often cultivated.

2. R. HUMILIS Marsh. PASTURE ROSE. Stem erect, branched, usually armed with stout stipular prickles and with bristles, but sometimes nearly smooth, 1–3 ft. tall; leaves mostly 5-foliate, stipules entire; leaflets oblong-lanceolate or oval, shining above, pale beneath, sharply serrate; flowers solitary or 2–3 together, 2–3 in. broad, pink; peduncles and calyx glandular-pubescent; calyx lobes foliaceous, spreading, finally deciduous; styles distinct; fruit globose, hispid. May–June. On dry soil; our most common wild rose.

3. R. RUBIGINOSA L. SWEETBRIER. Stem erect or curving, armed with stout recurved prickles; leaves 5–7-foliate; leaflets broadly oval, coarsely serrate, glandular-hispid beneath, aromatic; flowers usually solitary, white or pink; sepals widely spreading, deciduous; fruit obovate, slightly hispid. May–June. Common in cultivation.

4. R. LAEVIGATA Michx. CHEROKEE ROSE. Stem long, diffuse or trailing, armed with very stout recurved prickles; leaves mostly 3-foliate, persistent; leaflets smooth and shiny, lanceolate, hispid below along the mid-rib, stipules deciduous; flowers solitary, large, white; calyx very bristly; fruit globose. April–May. Common in cultivation and along fences.

57. POMACEÆ. APPLE FAMILY.

Trees or shrubs; leaves alternate, petiolate, stipulate, pinnately veined, or pinnately compound; flowers perfect, regular, solitary or clustered; calyx 5-parted, its tube coherent with the ovary; petals 5; stamens usually numerous, both petals and stamens inserted on the tube of the calyx; styles

2–5, distinct or united at the base, ovary usually 5-celled, carpels leathery, 1–4-seeded; fruit fleshy, formed of the thickened walls of the calyx-tube and ovary.

I. PYRUS.

Trees; leaves simple, stipules small, deciduous; flowers in terminal cymes, large, white or pink; calyx urn-shaped, 5-cleft, sepals acute; petals rounded, short-clawed; stamens numerous; styles 5, distinct or slightly united at the base; fruit pear-shaped, flesh with numerous hard grains.

P. COMMUNIS L. PEAR. A tree, often very large, head usually pyramidal; branches often thorny; leaves thick and leathery, ovate or oval, acute, finely serrate or entire, pubescent when young, becoming smooth with age; petioles slender; cymes few–several-flowered, terminal, and at the ends of "fruit spurs" grown the previous season; flowers white; styles not united; fruit obovate. March–April. A European and Asiatic tree common in cultivation.

II. MALUS.

Trees or shrubs; leaves simple, toothed or lobed, stipules deciduous; flowers cymose, white or pink; calyx tube urn-shaped, 5-lobed, lobes acute, spreading, persistent; styles 2–5, mostly 5, united at the base; ovary 5-celled, seeds 1–4 in each cell; fruit globose, usually depressed or hollowed at the extremities, flesh without hard grains.

1. M. ANGUSTIFOLIA (Ait.) Michx. CRAB-APPLE. A small tree with smooth, light gray bark; leaves lanceolate or oblong, serrate, pubescent when young, acute at the base, short-petioled; corymbs few-flowered; flowers pink, fragrant, about 1 in. broad; styles smooth, distinct; fruit nearly globose, about $\frac{3}{4}$ in. in diameter, very sour. March–April. In open woods.

2. M. MALUS (L.) Britt. APPLE. A tree with a rounded top and dark-colored bark; leaves oval or ovate, obtuse or pointed, dentate or nearly entire, rounded at the base, smooth above, pubescent beneath; cymes few–many-flowered; flowers large, white or pink; calyx pubescent; fruit depressed-globose to ovoid, hollowed at the base and usually at the apex. March–April. Cultivated from Europe.

III. CYDONIA.

Shrubs; very similar to *Malus*, but flowers usually solitary; carpels many-seeded, and fruit tomentose.

1. C. VULGARIS Pers. QUINCE. Shrub 6–12 ft. high; leaves oblong-ovate, acute at the apex, obtuse at the base, entire, tomentose below; flowers large, white or pink; fruit ovoid, tomentose. March–April. Cultivated.

2. C. JAPONICA Pers. JAPAN QUINCE. A widely branching shrub, 3–6 ft. high, branches with numerous straight spines; leaves ovate-lanceolate, acute at each end, glabrous and shining, serrulate; stipules conspicuous, reniform; flowers in nearly sessile axillary clusters, bright scarlet; fruit globose, rare. February–April. Common in cultivation.

IV. AMELANCHIER.

Shrubs or small trees with smooth gray bark; leaves simple, sharply serrate, petioled; flowers white, in racemes; calyx tube 5-cleft, adnate to the ovary; petals oblong; styles 5, united below, ovary 5-celled, 2 ovules in each cell, often only 1 maturing; fruit small, berry-like.

A. CANADENSIS (L.) Medic. SERVICE BERRY. A small tree, branches tomentose when young, soon becoming smooth; leaves ovate to elliptical, finely and sharply serrate, acute at the apex, usually obtuse or cordate at the base; racemes slender, many-flowered, appearing before or with the leaves; flowers showy; petals 4 or 5 times the length of the smooth sepals; fruit globose, dark red, edible. February-March. In rich woods; extremely variable in height, and in shape of leaves.

V. CRATÆGUS.

Shrubs or small trees, mostly with numerous strong spines, wood very hard; leaves serrate, lobed or deeply incised, petioled; flowers white or pink, in terminal corymbs or sometimes solitary; calyx tube urn-shaped, 5-cleft, the limb persistent; petals orbicular; stamens few or many; styles 1–5, distinct, ovules 1 in each cell; fruit a small pome with bony carpels.

1. C. CRUS-GALLI L. COCKSPUR THORN. Small trees with spreading branches; spines usually numerous, long and stout, but

sometimes few or wanting; leaves thick, oval or obovate, shining above, paler below, obtuse or acute, and sharply serrate at the apex, cuneate and entire at the base; corymbs terminal, many-flowered, smooth; flowers about $\frac{1}{2}$ in. wide; styles 1–3; fruit red, subglobose, $\frac{1}{2}$ in. in diameter. April–May. Common in open woods.

2. C. SPATHULATA Michx. SMALL-FRUITED HAW. A small tree, young twigs tomentose; spines 1–2 in. long; leaves small, spatulate, crenate at the rounded apex, entire and cuneiform below, coriaceous, glabrous, stipules lunate; corymbs compound, many-flowered; flowers small; calyx lobes very short; styles 5; fruit red, about the size of a small pea. March–April. On river banks.

3. C. APIIFOLIA (Marsh) Michx. CUT-LEAVED HAW. A small tree with stout spines; the young branches, leaves, and corymbs whitened with short hairs; leaves long-petioled, broadly deltoid, deeply incised and toothed; corymbs compound, many-flowered; flowers about $\frac{1}{2}$ in. broad; calyx lobes linear, glandular-pubescent; styles 1–3, filiform; fruit bright red, glabrous, small. March–April. River swamps.

4. C. FLAVA Ait. YELLOW HAW. A small tree with very numerous spines; leaves obovate, glandular-serrate at the rounded apex, cuneate below, pubescent when young; petiole short; corymbs few-flowered, slightly pubescent; flowers $\frac{1}{2}$–$\frac{3}{4}$ in. wide; calyx lobes entire or glandular-serrate; styles 4–5; fruit pear-shaped, $\frac{1}{2}$ in. or more in length, greenish-yellow. April–May. On sandy soils.

58. DRUPACEÆ. PLUM FAMILY.

Trees or shrubs; leaves alternate, simple, often glandular; stipules soon deciduous; flowers clustered or solitary, perfect, regular; calyx tube obconic, limb 5-parted; petals 5; stamens numerous, both petals and stamens inserted on the summit of the calyx tube; pistil 1, style 1, stigma usually capitate, ovary 1-celled, 2-ovuled, but usually only one ovule maturing; fruit a drupe.

I. PRUNUS.

Trees or shrubs, often spiny; leaves serrate; flowers mostly in axillary clusters; calyx 5-cleft, deciduous; petals 5, spreading; stamens 15–25; style terminal; fruit a drupe, exocarp fleshy, smooth, endocarp hard and bony, somewhat roughened, oval and compressed or subglobose.

A. Stone oval, compressed, leaves convolute in the bud, branches often spiny. (Plums.)

1. P. Americana Marsh. Wild Plum. A small tree, bark thick and rough, branches spiny; leaves ovate or obovate, acuminate at the apex, rounded or cordate at the base, sharply serrate, rather thick, pubescent beneath; petioles glandular; flowers in lateral, sessile umbels, appearing with or before the leaves; pedicels $\frac{1}{2}$–$\frac{3}{4}$ in. long; flowers $\frac{1}{2}$–$\frac{3}{4}$ in. in diameter; calyx pubescent within; drupe globose, red or yellow, $\frac{1}{2}$–1 in. in diameter. March–April. Common in woods.

2. P. angustifolia Michx. Chickasaw Plum. A small tree with spiny branches; leaves lanceolate or oblong-lanceolate, acute at the apex, usually obtuse at the base, finely and sharply serrate, rather thin, smooth; flowers in lateral, sessile umbels, pedicels short; calyx smooth; drupe yellowish-red, subglobose, skin thin, stone only slightly compressed. March–June. In old fields.

B. Stone globose or slightly compressed, leaves folded in the bud, branches not spiny. (Cherries.)

3. P. serotina Ehrh. Wild Black Cherry. Often becoming a large tree; bark on old trees rough, nearly black; leaves rather thick, oval to lanceolate-ovate, acute or acuminate at the apex, finely serrate with calloused teeth, glabrous above, pubescent on the veins beneath; racemes terminal, long and spreading; flowers white; drupes globose, about $\frac{1}{4}$ in. in diameter, purplish-black. April–May. In rich woods.

4. P. Caroliniana Ait. Cherry Laurel. A small tree; leaves evergreen, coriaceous, smooth and shiny, ovate or ovate-lanceolate, acute, nearly entire; racemes axillary, shorter than the leaves; flowers white; drupe small, black, ovoid, not edible, soon becoming dry. February–March. On river banks, and often cultivated for ornament.

5. P. Cerasus L. Cherry. Often becoming a large tree; leaves oval or ovate, acute or acuminate at the apex, rounded at the base, irregularly serrate-dentate, smooth on both sides, resinous when young; flowers in lateral umbels, white; pedicels long and slender; drupe globose, red or black. March–April. This is the European species from which most of our cultivated varieties have been developed.

II. AMYGDALUS.

Small trees; leaves simple, lanceolate, serrate, short-petioled; flowers solitary or clustered, like those of *Prunus*;

exocarp fleshy, velvety, endocarp hard and bony, compressed, deeply furrowed and pitted.

A. Persica L. Peach. A tree with a rounded top; bark nearly smooth; leaves lanceolate, acuminate, finely serrate, smooth on both sides; petioles usually bearing 2 or 4 crescent-shaped or cup-shaped glands; flowers pink, scaly-bracted; drupe ovoid, with a suture along one side. February-March. Often escaped from cultivation.

III. CHRYSOBALANUS.

Low shrubs; leaves nearly sessile, entire; stipules minute; flowers in terminal and axillary cymes or panicles, small; calyx 5-cleft, persistent; petals 5; stamens numerous; pistil 1, ovary with 2 ovules of which only 1 matures; fruit a drupe.

C. oblongifolius Michx. Hog Plum. Bush low and straggling, seldom more than 1 ft. in height, unarmed; leaves coriaceous, narrowly obovate or cuneiform, mucronate, smooth on both sides or pubescent beneath, 3-4 in. long; cymes mostly terminal, many-flowered, but most of the flowers abortive, greenish-yellow; calyx pubescent; ovary smooth; drupe ovoid, nearly white, 1 in. or more in length, edible, stone grooved on one side. April–May. Dry sandy barrens.

59. MIMOSACEÆ. MIMOSA FAMILY.

Herbs, shrubs or trees; leaves alternate, pinnate, sometimes 2–3 times pinnately compound; stipules small; flowers in long-peduncled heads or racemes, regular, hypogynous; petals 3-6, distinct or slightly united; stamens as many as the petals or more numerous, distinct or united; pistil 1, ovary 1-celled, ovules several; fruit a legume.

I. ACUAN.

Shrubs or perennial herbs; stems erect or diffuse, smooth; leaves abruptly twice-pinnate; stipules small; flowers in heads or spikes on axillary peduncles, the upper perfect, the lower often staminate or neutral; calyx 5-toothed; corolla of

5 distinct petals or 5-cleft; stamens 5–10, distinct; ovary nearly sessile, flat, several-seeded.

A. Illinoensis (Michx.) Kuntze. Desmanthus. Stem erect or ascending, glabrous, 1–4 ft. high; pinnæ 6–14 pairs, each with a minute gland at the base; leaflets 20–30 pairs, small, linear; heads globose; stamens 5; legumes several, on a peduncle 2–3 in. long, curved, flat, 2-valved, 3–6-seeded. May–July. Open sandy fields.

II. MORONGIA.

Perennial herbs; stems decumbent or prostrate, prickly, 2–5 ft. long; leaves bi-pinnate; stipules setaceous; flowers perfect or polygamous, in axillary peduncled heads; calyx minute; corolla tubular, 5-cleft; stamens 8–10, distinct; legume long, prickly, 1-celled.

M. angustata (T. & G.) Britt. Sensitive-brier. Stem armed with numerous, weak, recurved prickles; leaves petioled, pinnæ 4–6 pairs; leaflets 12–15 pairs, linear, elliptical, very faintly veined; flowers pink, in dense heads, peduncles shorter than the leaves; legumes narrowly linear, long-pointed, prickly, 4-valved, several-seeded. May–August. On dry soil.

III. ACACIA.

Trees or shrubs; leaves pinnately compound or decompound; flowers perfect or polygamous, in spikes or heads; calyx 4–5-toothed; petals 4–5, distinct or united; stamens numerous, distinct; legumes 2-valved, many-seeded.

1. A. Farnesiana Willd. Opoponax. Shrubs; stem spiny, branching, glabrous, 2–4 ft. high; leaves twice-pinnate; leaflets very numerous, small, narrowly oblong; stipules large spines; heads on long axillary peduncles; flowers yellow, fragrant; legume long and slender, twisted. May–July. Introduced in waste places.

2. A. Julibrissin Willd. Crimson Acacia. A large shrub; stem erect, smooth, glabrous; leaves decompound, pinnæ 8–12 pairs; leaflets 25–30 pairs, oblong, oblique; heads few-flowered, in terminal panicles; flowers large; stamens bright crimson, exserted, 3–4 in. long; legume flat, few-seeded. May–July. Introduced and escaped from gardens.

60. CÆSALPINACEÆ. SENNA FAMILY.

Trees, shrubs or herbs; leaves simple or compound, alternate, usually stipulate; flowers variously clustered, perfect, polygamous or monœcious, regular, or irregular and somewhat papilionaceous; calyx usually of 5 distinct or united sepals; petals usually 5, the upper enclosed by those on the sides; stamens 10 or less, usually distinct; ovary 1-celled, usually several-seeded, fruit a legume.

I. CERCIS.

Trees; leaves simple, stipulate; flowers in axillary clusters, papilionaceous; calyx bell-shaped, 5-toothed; stamens 10, distinct; ovary short-stipitate, ovules several; fruit a flattened legume.

C. CANADENSIS L. REDBUD. A small tree, 10–20 ft. high, wood hard but weak, bark smooth, dark-colored; leaves broadly cordate, abruptly acute, rather thick, very smooth above, often slightly pubescent below; flowers several in a cluster, appearing before the leaves, pinkish-purple; legume oblong, compressed, many-seeded. February–March. Common on rich soil.

II. CASSIA.

Shrubs or herbs; leaves abruptly pinnately compound, stipulate; flowers mostly yellow; sepals nearly regular, slightly united below; petals 5, somewhat unequal; stamens 5 or 10, often partly irregular or abortive; legume many-seeded, seeds often separated by cross partitions.

1. C. TORA L. LOW SENNA. Annual herbs; stem stout, erect, branched, glabrous, 2–3 ft. high; leaves petioled; leaflets usually 6, 1–1½ in. long, obovate, mucronate, entire, with a small slender gland between the lowest pair; stipules deciduous; flowers usually in pairs, ¾–1 in. broad; stamens 10, the anthers of 3 being imperfect; legume linear, curved, 4–6 in. long. June–August. On rich moist soil.

2. C. OCCIDENTALIS L. COFFEE SENNA. Annual; stem erect, widely branched, glabrous; leaves petioled; leaflets 8–12, 1–2 in. long, broadly lanceolate, acuminate at the apex, rounded at the

base, entire, glabrous, glands 2, conical; stipules subulate, deciduous; flowers in 2–4-flowered axillary racemes, $\frac{2}{3}$–$\frac{3}{4}$ in. broad; stamens 10, the 3 upper abortive; pod linear, erect, slightly curved, 3–4 in. long. June–August. Common in waste places.

3. C. CHAMÆCRISTA L. LARGE-FLOWERED SENSITIVE-PLANT. Annual; stem erect, widely branched and 1–2 ft. high, or nearly simple and 3–5 ft. high, rusty-pubescent or nearly smooth; leaves very sensitive, petioled; leaflets about $\frac{1}{2}$ in. long, linear-oblong, mucronate, petiolar gland cup-shaped; stipules nerved, persistent; flowers 2–5 together, on axillary pedicels, 1–1$\frac{1}{2}$ in. wide; petals yellow, often spotted with purple; stamens 10, all perfect; legume linear, pubescent, several-seeded. June–August. Common in waste places.

4. C. NICTITANS L. WILD SENSITIVE-PLANT. Annual; widely branched, stem smooth or pubescent, 10–18 in. high; leaflets 20–40, linear-oblong, mucronate, $\frac{1}{3}$–$\frac{2}{3}$ in. long; petiolar gland urn-shaped; stipules persistent, lanceolate, veined; flowers small, 2–3 together in nearly sessile axillary clusters; stamens 5; legume pubescent, narrowly oblong, few-seeded. June–October. Common on dry soil.

III. GLEDITSIA.

Large trees; bark dark-colored, nearly smooth; leaves usually pinnately decompound; leaflets serrate; flowers polygamous, in small spike-like racemes; calyx spreading, 3–5-cleft; petals as many as the sepals and inserted at the summit of the tube; stamens 5–10, distinct, inserted with the petals; ovary nearly sessile, ovoid or elongated; fruit a legume, 1 or many-seeded, pod coriaceous.

G. TRIACANTHOS L. HONEY LOCUST. A large tree, usually armed with stout, branched thorns which are sometimes a foot or more in length; leaves petioled, decompound; leaflets short-stalked, lanceolate-oblong, base inequilateral, smooth above, often pubescent below; racemes solitary or in small clusters, drooping; flowers inconspicuous, greenish; legume linear-oblong, often 12–15 in. long by 1 in. wide, twisted, many-seeded, glabrous and shiny, pulpy within. June–July. In rich woods. [The thorns are plainly modified branches bearing dormant buds, and often partially developed leaves. The early spring leaves are usually only once compounded, while those of later growth are almost invariably decompound. Often a single leaf will show both forms of compounding.]

61. PAPILIONACEÆ. PEA FAMILY.

Trees, shrubs, herbs or woody vines; leaves alternate, stipulate, mostly compound; flowers irregular, usually perfect, solitary or variously clustered; calyx 4–5-cleft or lobed, sometimes 2-lipped; petals 5, the upper and outer one (the *standard*) usually longer than the others and enclosing them, the two lateral (the *wings*) usually spreading, and the two lower (the *keel*) folded together and often united; stamens mostly 10, monadelphous or diadelphous, rarely distinct; corolla and stamens inserted in the base of the calyx; pistil 1, ovary 1-celled or sometimes 2-celled by the inwardly projecting suture, and sometimes transversely several-celled; fruit a legume, 1–many-seeded.

Leaves trifoliate.
- Legume several-seeded.
  - Plants erect.
    - Legume inflated . . . . I. Baptisia.
    - Legume nodulose . . . . XXVIII. Erythrina.
    - Legume separating into joints . XVII. Meibomia.
  - Plants twining or trailing.
    - Keel spirally twisted.
      - Inflorescence racemose . . XXVI. Phaseolus.
      - Inflorescence capitate . . XXVII. Strophostyles.
    - Keel not twisted.
      - Calyx 5-toothed.
        - Standard spurred . . . XXI. Bradburya.
        - Standard not spurred . . XXII. Clitoria.
      - Calyx 4-toothed . . . . XXIV. Galactia.
- Legume 1–few-seeded.
  - Leaflets serrate or denticulate.
    - Legume coiled . . . . IV. Medicago.
    - Legume not coiled.
      - Flowers racemed . . . V. Melilotus.
      - Flowers capitate . . . VI. Trifolium.

Leaflets entire.
  Leaflets glandular dotted.
    Flowers yellow . . . XXV. Rhynchosia.
    Flowers white or purplish . VII. Psoralea.
  Leaflets not dotted.
    Flowers yellow . . . XV. Stylosanthes.
    Flowers white or purplish . XVIII. Lespedeza.

Leaves odd-pinnate.
  Stems woody.
    Shrubs . . . . . VIII. Amorpha.
    Twining vines . . . . X. Kraunhia.
    Trees . . . . . XI. Robinia.
  Stems herbaceous, erect or diffuse.
    Keel spurred, pod 4-angled . XII. Indigofera.
    Keel not spurred, pod flat . IX. Cracca.
  Stems herbaceous, twining . . XXIII. Apios.

Leaves abruptly pinnate.
  Leaves with tendrils.
    Style bearded on the side nearest the keel . . . . . XIX. Vicia.
    Style bearded on the side opposite the keel . . . . . XX. Lathyrus.
  Leaves without tendrils.
    Legume 2-seeded . . . XIII. Glottidium.
    Legume many-seeded . . XIV. Sesban.

Leaves palmately compound.
    Leaflets several . . . III. Lupinus.
    Leaflets 2 or 4 . . . . XVI. Zornia.

Leaves simple.
    Legume inflated . . . II. Crotalaria.
    Legume flat, flowers yellow . XXV. Rhynchosia.
    Legume flat, flowers blue, pink or white . . . . III. Lupinus.

I. BAPTISIA.

Perennial herbs; stems erect, widely branched; leaves simple or palmately trifoliate; flowers in racemes; calyx 4–5-lobed, persistent, the upper lobe usually longer and emar-

ginate; standard orbicular, its sides reflexed, wings about as long as the keel; stamens 10, distinct; the pod stipitate, long-pointed by the remains of the style; plants usually becoming black in drying.

1. B. LANCEOLATA Ell. NARROW-LEAVED FALSE INDIGO. Stem pubescent when young, becoming smooth with age, 18–24 in. high; leaves trifoliate, on short petioles; leaflets lanceolate to obovate, obtuse at the apex, narrowed to the base, rather thick; stipules small and soon deciduous; flowers yellow, axillary and solitary, or in short racemes; ovary densely pubescent; mature legume globose or ovoid, coriaceous, long-pointed; plant blackening in drying. April–May. Dry pine barrens.

2. B. TINCTORIA R. Br. WILD INDIGO. Stem smooth, slender, 2–4 ft. high; branches slender; leaves trifoliate, on short petioles, the upper nearly sessile; stipules minute, quickly deciduous; leaflets obovate to oblanceolate, obtuse at the apex, cuneate at the base, entire; racemes numerous, terminal; flowers yellow, ½ in. long; legume globose-ovoid, on a stipe about the length of the calyx, point long and slender; plant blackening in drying. May–June. Common on dry, sandy soil.

3. B. ALBA (L.) R. Br. WHITE WILD INDIGO. Stem smooth and glaucous, often purple, 2–3 ft. high; branches slender, spreading; leaves petioled, trifoliate; stipules minute, soon deciduous; flowers white, mostly in a single raceme which is 1–3 ft. long, with occasionally lateral, few-flowered racemes; pod linear-oblong, the point very slender and soon deciduous; plant unchanged in drying. April–May. In damp soil.

4. B. AUSTRALIS (L.) R. Br. BLUE FALSE INDIGO. Stem smooth and glabrous, stout, 2–4 ft. high; leaves trifoliate, short-petioled; stipules lanceolate, persistent, longer than the petioles; leaflets oblong, wedge-shaped or narrowly obovate, entire; flowers bright blue, 1 in. long, in terminal, erect, loosely flowered racemes; stipe about the length of the calyx; pod oblong, with a slender, persistent point. May–July. Banks of rivers; often cultivated for ornament.

II. CROTALARIA.

Annual or perennial herbs, sometimes with a woody base; leaves simple; stipules inversely sagittate and decurrent; flowers yellow, in few-flowered racemes opposite the leaves; calyx 5-toothed and often 2-lipped; standard cordate, keel falcate; stamens monadelphous, 5 of the anthers smaller

and more rounded than the others; pod inflated and purple at maturity, seeds many, becoming loose in the pod.

1. C. SAGITTALIS L. RATTLE-BOX. Annual; stem widely branching, 3–6 in. high, clothed with brownish hairs; leaves nearly sessile, oval or oblong-lanceolate, hairy; stipules often wanting below; racemes short, 2–3 flowered; corolla about the length of the calyx; pod oblong, glabrous, much inflated. May–July. Barren, sandy soil.

2. C. PURSHII DC. NARROW-LEAVED RATTLE-BOX. Perennial; root slender-fusiform; stems erect, slender, with scattered hairs, 12–18 in. high; lower leaves oval or oblong, the upper linear, thick and fleshy; racemes 6–12 in. long, 5–10-flowered, flowers distant; corolla much longer than the calyx; pod inflated, dark purple. May–June. Grassy pine barrens.

III. LUPINUS.

Biennial or perennial herbs; leaves simple or palmately compound; flowers showy, in terminal racemes; calyx 2-lipped, 5-toothed; standard orbicular, with the sides reflexed, keel falcate; stamens monadelphous, anthers alternately oblong and roundish; ovary sessile; matured pod oblong, several-seeded, often compressed between the seeds.

1. L. VILLOSUS Willd. WOOLLY LUPINE. Biennial; stem erect, branching at the base, 12–18 in. high; leaves simple, long-petioled, narrowly oblong or elliptical, acute at each end; stipules linear, sometimes 2 in. long, adnate to the petiole below; flowers red and purple, in dense terminal spikes or racemes 6–10 in. long; legume oblong; whole plant densely silvery-tomentose. April–May. Dry, sandy barrens.

2. L. PERENNIS L. Perennial; stem erect, pubescent, 12–18 in. high; leaves palmately 7–9 foliate; leaflets obovate or oblanceolate, obtuse and mucronate at the apex, slightly pubescent; petiole slender; stipules small; racemes terminal, slender, loosely many-flowered; flowers purple, blue, pink or white; legume oblong, densely pubescent, few-seeded. April–May. Dry, sandy soil.

IV. MEDICAGO.

Annual or perennial herbs; leaves petioled, trifoliate; leaflets toothed; flowers in terminal and axillary spikes or racemes; calyx 5-toothed, the teeth short and slender; stand-

ard oblong, much longer than the wings or keel; stamens 10, diadelphous; ovary sessile; legume 1–several-seeded, coiled, indehiscent, often spiny.

1. M. SATIVA L. ALFALFA. Perennial; stems erect, branching, pubescent when young, becoming smooth with age, 2–3 ft. high; leaves short-petioled; leaflets obovate, sharply dentate towards the apex, obtuse or sometimes emarginate or mucronate; stipules lanceolate, entire; flowers blue, small, in rather close spikes; legumes pubescent, coiled, few-seeded. April–September. Introduced from Europe, and cultivated for hay and pasture.

2. M. ARABICA All. BUR CLOVER. Annual; stem procumbent, glabrous or slightly pubescent, 1–3 ft. long; leaves long-petioled; leaflets obcordate, toothed above, usually with a dark spot near the center; stipules inequilateral, incised or toothed; flowers small, yellow, in globose spikes; mature legume nearly globose, several times coiled, reticulated and spiny-toothed. April–June. Introduced from Europe and often cultivated for pastures.

V. MELILOTUS.

Annual or biennial herbs; leaves petioled, trifoliate; flowers small, white or yellow, in dense axillary and terminal racemes; calyx 5-toothed, the teeth nearly equal; standard erect, wings and keel cohering; stamens 10, diadelphous; legume longer than the calyx; 1–4-seeded.

M. ALBA Desv. MELILOTUS. Biennial; stem erect, branching, smooth or the young branches slightly pubescent; leaflets oblong or oblanceolate, rounded or truncate at the apex, serrate; stipules small; racemes long, slender, erect; flowers white; standard longer than the wings and keel; legume ovoid, rugose, drooping, mostly 1-seeded, scarcely dehiscent. April–October. Common on lime soil and widely cultivated.

VI. TRIFOLIUM.

Annual, biennial or perennial herbs; stems more or less diffuse; leaves petioled, trifoliate; leaflets toothed or serrate; stipules adnate to the petioles; flowers white, yellow or red, in heads; calyx 5-cleft, the teeth nearly equal and subulate; petals withering-persistent, keel shorter than the wings; stamens diadelphous; legume smooth, 1–6-seeded, scarcely dehiscent.

1. T. PROCUMBENS L. Low Hop-clover. Annual; stem slender, erect, diffuse or decumbent, pubescent, 6–10 in. long; leaves short-petioled; leaflets obovate or obcordate, finely dentate, the middle one distinctly stalked; stipules lance-ovate; flowers yellow, reflexed in fruit; legume 1-seeded. February–April. Common on clay soil in waste places.

2. T. INCARNATUM L. Crimson Clover. Annual; stem erect, somewhat branched, pubescent, 1–2 ft. high; lower leaves long-, the upper short-petioled; leaflets obovate or cuneate, toothed at the apex; flowers bright crimson, sessile, in terminal heads which finally become much elongated; calyx silky, its lobes long and plumose. March–April. Introduced and cultivated for fodder.

3. T. PRATENSE L. Red Clover. Biennial or short-lived perennial; stems diffuse, branching, becoming decumbent, pubescent, 1–3 ft. long; leaves long-petioled; stipules large; leaflets oval to obovate, finely toothed, often with a dark triangular spot near the center; flowers red or purple, in globose heads, erect in fruit; calyx teeth setaceous, hairy; legume 1–3-seeded. April–September. Introduced and widely cultivated.

4. T. REFLEXUM L. Buffalo Clover. Annual or biennial; stem erect or ascending, pubescent, 8–15 in. long; leaves long-petioled; stipules ovate, acuminate; leaflets obovate, denticulate, prominently straight-veined; heads globose, peduncled; flowers rather large, reflexed in fruit; calyx shorter than the corolla, the teeth linear; standard red or pink, wings and keel white; legume 3–5-seeded. April–May. Along fences and ditch banks on rich soil.

5. T. CAROLINIANUM Michx. Carolina Clover. Perennial; stems diffuse or ascending, much-branched, pubescent, 6–10 in. long; leaves short-petioled; leaflets small, obovate or obcordate, slightly toothed; heads small, globose, on long peduncles; flowers white, tinged with purple, reflexed in fruit; legume 4-seeded. March–April. Common in waste places.

6. T. REPENS L. White Clover. Perennial; stems widely branching at the base, prostrate and creeping, nearly smooth, 6–12 in. long; leaves long-petioled; leaflets oval, obovate or obcordate, denticulate; heads globose, long-peduncled; flowers white, reflexed in fruit; legume 3–4-seeded. April–November. Introduced; common about houses and in pastures.

VII. PSORALEA.

Perennial herbs; whole plant glandular-dotted; leaves 3–5-foliate; stipules cohering with the petioles; flowers in axillary or terminal spikes or racemes; calyx 5-cleft, the lobes

nearly equal; standard ovate or orbicular, keel incurved, obtuse; stamens monadelphous or diadelphous, 5 of the anthers often abortive; ovary nearly sessile; pod included in the calyx, often wrinkled, indehiscent, 1-seeded.

P. PEDUNCULATA (Mill.) Vail. SAMSON'S SNAKEROOT. Stem erect, slender, branching above, pubescent, 1–2 ft. high; leaves trifoliate; petioles shorter than the leaflets; stipules subulate; leaflets elliptical or oblong-lanceolate, sparingly glandular-dotted, the terminal one stalked; loosely flowered spikes axillary and terminal, on peduncles much longer than the leaves; flowers blue or purple, about $\frac{1}{3}$ in. long; pod compressed-globose, wrinkled transversely. May–June. Dry soil.

VIII. AMORPHA.

Small shrubs, glandular-dotted; leaves odd-pinnate; flowers purple, blue or white, in slender spikes or racemes; calyx 5-toothed, persistent; standard obovate, concave, wings and keel none; stamens monadelphous, long-exserted; ovary sessile; legume curved, glandular-roughened, 1–2-seeded, indehiscent.

1. A. FRUTICOSA L. FALSE INDIGO. A shrub 6–15 ft. high, with smooth, dark-brown bark; leaves petioled; leaflets 15–21, short-stalked, oblong, obtuse or emarginate, sparingly punctate with pellucid dots; slender flowering spikes panicled or solitary, 4–6 in. long; flowers blue or purple; calyx teeth short, nearly equal, pubescent; pod glandular. May–June. River banks.

2. A. CANESCENS Pursh. LEAD-PLANT. A diffuse shrub 1–2 ft. high; branches and leaves covered with a dense, lead-colored pubescence; leaves sessile; leaflets very numerous, crowded, small, elliptical; spikes short, clustered, densely flowered; flowers bright blue; pod a little longer than the calyx, 1-seeded. June–July. On dry hills.

IX. CRACCA.

Perennial herbs; leaves odd-pinnate; stipules small; leaflets entire; flowers in terminal and axillary racemes or clusters; calyx about equally 5-cleft; standard orbicular, reflexed, silky on the outside, about as long as the coherent wings and keel; stamens monadelphous or diadelphous; legume linear, compressed, several-seeded.

1. C. Virginiana L. Catgut. Root long, slender and very tough; stems clustered, erect, slender, seldom branched, silky-pubescent, 1–2 ft. high; leaves nearly sessile; leaflets 15–25, linear-oblong, acute or obtuse, smooth above, white-canescent below; racemes mostly in a dense terminal cluster; flowers large, showy, yellowish-purple; pod linear, straight, densely pubescent. June–July. Dry pine barrens.

2. C. spicata (Walt.) Kuntze. Goat's Rue. Stems diffuse, simple or branched, villous with rusty hairs; leaves scattered, short-petioled; leaflets 9–15, oval, strongly mucronate at the apex, smoothish above, hairy below; racemes opposite the leaves, peduncle slender, 6–10 in. long, 6–10-flowered; flowers large, white, becoming purple; calyx lobes linear-subulate; pod linear, pubescent, 10–12-seeded. May–July. Dry pine barrens.

3. C. hispidula (Michx.) Kuntze. Goat's Rue. Stems slender, ascending or decumbent, rusty-pubescent, 1–2 ft. long; leaves short-petioled; leaflets 11–15, small, oblong, acute or obtuse, usually smooth above; peduncles lateral or terminal, slender, a little longer than the leaves, 2–4-flowered; flowers small, purple; pod linear, pubescent, slightly curved. May–July. Dry, sandy soil.

X. KRAUNHIA.

Twining woody vines; leaves odd-pinnate; racemes terminal; flowers large and showy; calyx 2-lipped, the upper lip 2-cleft, short, the lower longer and 3-cleft; standard large, orbicular, with 2 calloused ridges at the base, wings auriculate at the base, keel falcate; pod long, stipitate, coriaceous, 2-valved, several-seeded.

K. frutescens (L.) Greene. Wistaria. Stem climbing 30–40 ft., often 2–3 in. in diameter at the base; branches and leaves pubescent when young, becoming smoother with age; leaves short-petioled; stipules minute; leaflets 9–17, ovate-lanceolate, acute at the apex, rounded at the base; racemes large, densely flowered; calyx pubescent; corolla lilac-purple; pod 2–3 in. long, 2–4-seeded. April–June. River banks. Often cultivated for ornament.

XI. ROBINIA.

Trees or shrubs; leaves odd-pinnate; stipules often spiny; flowers showy, in axillary racemes; calyx short, 5-toothed, the two upper teeth shorter and partially united; standard

large, orbicular, reflexed, keel obtuse; stamens diadelphous; style bearded on one side; legume compressed, several-seeded.

R. PSEUDACACIA L. BLACK LOCUST. A tree of medium size; bark rough and nearly black; twigs and leaves smooth; leaflets 9–15, ovate or oblong, obtuse and slightly mucronate at the apex; stipules forming persistent spines; racemes loose, pendulous, 3–5 in. long; flowers white, fragrant; pod smooth, 4–8-seeded. April–May. Introduced and quite common; wood very durable when exposed to the weather, and extensively used for posts.

XII. INDIGOFERA.

Herbs or shrubs; leaves odd-pinnate; stipules small; flowers in terminal and axillary racemes; calyx 5-toothed, oblique; standard orbicular, erect, keel erect, with a spur on each side; stamens diadelphous; legume slender, 1–many-seeded.

I. LEPTOSEPALA Nutt. WILD INDIGO. Perennial; stem decumbent, rough hairy, 2–3 ft. long; leaves short-petioled; leaflets 5–9, short-stalked, linear-oblong; racemes peduncled, 6–15-flowered; flowers red; pods not stipitate, linear, pendulous, septate between the seeds which are truncate at each end. May–August. On open ground.

Besides the indigenous species described, I. TINCTORIA L. and I. ANIL L. were formerly cultivated for the manufacture of indigo, and occasional plants are still found in waste places.

XIII. GLOTTIDIUM.

Annual; leaves abruptly pinnate; flowers in axillary racemes; calyx 5-toothed, oblique; standard erect, reniform; stamens diadelphous; style abruptly curved at the apex; legume long-stipitate, narrowly elliptical, compressed, the outer and inner coats separating at maturity, 2-seeded.

G. FLORIDANUM (Willd.) DC. COFFEE-WEED. Stem yellowish-green, smooth, erect, widely branched, 4–8 ft. high; leaflets numerous, oblong-linear; racemes long-peduncled, often compound; flowers yellow, near the summit of the peduncle; legume 2 in. long. July–September. Introduced; common on dry soil.

XIV. SESBAN.

Herbs or shrubs; leaves abruptly pinnate; flowers red or yellow, in axillary racemes; calyx equally 5-toothed, with 2 deciduous bracts; standard erect, orbicular; stamens diadelphous; ovary stipitate; legume long, slender, many-seeded.

S. MACROCARPA Muhl. LONG-POD COFFEE-WEED. Annual; stems erect, smooth, widely branched, 5–10 ft. high; leaflets very numerous, oblong-linear, obtuse, mucronate; racemes 1–4-flowered, shorter than the leaves; flowers yellow and red; legume very slender, knotted, pendulous, 4-angled, many-seeded, 8–12 in. long. June–September. Damp soil.

XV. STYLOSANTHES.

Perennial; stems slender, branching, wiry; leaves trifoliate; stipules sheathing and adnate to the petioles; flowers in terminal heads or short spikes; calyx tube slender, campanulate, unequally 4–5-cleft, the lower lobe longer; standard erect, orbicular; stamens monadelphous, alternate stamens longer; style filiform, the upper part deciduous, the lower persistent and hooked at the end; pod 1–2-jointed, the lower joint empty.

S. BIFLORA (L.) B. S. P. Stems diffuse or ascending, pubescent or hispid; leaflets lanceolate or elliptical, rigid, veins straight, nearly white; heads few-flowered; flowers yellow, bracts bristly; pod obovate, reticulate, 2-jointed, 1-seeded. May–August. On dry soil.

XVI. ZORNIA.

Perennial herbs; leaves petioled, palmately 2–4-foliate; stipules small, sagittate; flowers in slender, axillary racemes; floral bracts conspicuous; calyx 2-lipped, 5-cleft; standard orbicular; stamens monadelphous, alternately shorter; legume compressed, 2–5-jointed, joints 1-seeded.

Z. BRACTEATA (Walt.) Gmel. ZORNIA. Stems from long and woody roots, smooth or pubescent, decumbent or prostrate, widely branched, 2–3 ft. long; leaves 4-foliate; leaflets narrowly elliptical to oblong-ovate, acute at each end; racemes 4–20-flowered, becom-

ing much elongated in fruit; flowers yellow, nearly concealed by large, ovate, veiny bracts; pods flat, hispid, 2–5-jointed. May–August. Dry, sandy soil.

XVII. MEIBOMIA.

Perennial herbs; sometimes woody at the base; leaves petioled, trifoliate, stipulate; leaflets stalked, stipellate; flowers in terminal racemes or panicles; calyx 2-lipped, the upper lip entire or emarginate, the lower 3-cleft; stamens monadelphous or diadelphous; ovary sessile or stalked; legume flattened, separating into joints, hispid with hooked hairs.

1. M. GRANDIFLORA (Walt.) Kuntze. POINTED-LEAVED BEGGAR-WEED. Stem erect, glabrous or pubescent, 2–4 ft. high; leaves mostly crowded at the summit of the stem; petioles long; stipules small; leaflets thin, ovate or roundish, acuminate, smooth or slightly pubescent on both sides; panicle terminal, long-peduncled, large, many-flowered; flowers large, purple; stipe much longer than the calyx tube; legume 2–4-jointed, joints half-obovate, concave on the back, hispid. June–September. In rich woods.

2. M. NUDIFLORA (L.) Kuntze. NAKED-FLOWERED BEGGAR-WEED. Stems smooth, erect, the sterile about 10 in. high, bearing a cluster of leaves at its summit; leaflets ovate, the middle one long-stalked, acute or obtuse at the apex, often inequilateral, entire, pale beneath; fertile stems usually leafless, $1\frac{1}{2}$–3 ft. high, bearing a narrow panicle of small purplish flowers; legume long stipitate, 2–3-jointed, joints straight on the back. June–August. In rich woods.

3. M. CANESCENS (L.) Kuntze. HOARY BEGGAR-WEED. Stem erect, much-branched, rough, hairy, striate, 3–5 ft. high; leaves petioled; stipules large, ovate, acuminate; leaflets ovate, usually acute, very rough, hairy; racemes terminal, compound; flowers purple, $\frac{1}{4}$–$\frac{1}{3}$ in. long; legume sessile, 3–6-jointed, joints convex on the back, rounded below, very hispid. June–August. Dry, open woods.

XVIII. LESPEDEZA.

Annual or perennial herbs; leaves trifoliate; flowers small, in axillary clusters, often of 2 kinds, the larger showy and perfect, but sterile, the smaller inconspicuous, pistillate and fertile; calyx tube 5-cleft, the lobes nearly equal; stamens diadelphous, anthers alike; legume small, flat, 1-seeded, indehiscent.

1. L. REPENS (L.) Bart. CREEPING LESPEDEZA. Perennial; stem slender, prostrate, spreading, smooth or slightly tomentose; leaves nearly sessile; leaflets small, oval or elliptical, obtuse or emarginate at the apex; the petaliferous flowers on slender peduncles longer than the leaves, the fertile flowers nearly sessile; legume orbicular, finely pubescent. June–September. Dry, sandy soil.

2. L. VIOLACEA (L.) Pers. BUSH LESPEDEZA. Perennial; stem erect, spreading or diffuse, slightly pubescent, 1–3 ft. high; leaves short-petioled; stipules subulate; leaflets oval or elliptical, rounded at both ends, pubescent beneath; peduncles of the petaliferous flowers longer than the leaves, flowers rather large, purple; fertile flowers in nearly sessile axillary clusters; legume flat, oval, much longer than the calyx, smooth or slightly pubescent. Plant extremely variable in habit of growth. June–September. Common in dry woods.

3. L. STRIATA (Thunb.) H. & A. LESPEDEZA, JAPAN CLOVER. Annual; stem diffuse or ascending; slender, wiry, sparingly pubescent, 6–18 in. long; leaves numerous, nearly sessile; leaflets oblong-obovate, margins ciliate; flowers in nearly sessile, axillary clusters; corolla pink or purple; pod oval, acute, longer than the calyx lobes. June–October. Introduced from Japan and very common.

XIX. VICIA.

Annual or perennial herbs; leaves pinnate, tendril-bearing; stipules half-sagittate; flowers on axillary peduncles; calyx 5-toothed, the two upper teeth obovate; standard obovate, emarginate, wings adherent to the keel; stamens mostly diadelphous; style filiform, hairy, at least on the side facing the keel; legume 2–several-seeded.

1. V. SATIVA L. COMMON VETCH. Annual; stem simple, smooth or pubescent, reclining, 1–3 ft. long; leaves short-petioled; leaflets 5–7 pairs, obovate-oblong to linear, obtuse, emarginate and mucronate at the apex; flowers in pairs, nearly sessile in the axils, pale purple, $\frac{3}{4}$–1 in. long; legume linear, several-seeded. March–April. Introduced from Europe and common in cultivation.

2. V. LUDOVICIANA Nutt. LOUISIANA VETCH. Perennial; stem smooth or slightly pubescent, angled, diffuse, 2–3 ft. long; leaves petioled; stipules small; leaflets 4–6 pairs, oblong or obovate, retuse at the apex; peduncles about as long as the leaves, mostly 2-flowered; flowers small, light blue; legume broadly falcate, 4–6-seeded. April–May. In rich woods.

3. V. VILLOSA L. HAIRY VETCH. Annual; stem diffuse, angled, pubescent, 4–10 ft. long; leaves short-petioled; stipules large; leaflets 10–20 pairs, cuneiform, retuse and mucronate at the apex, pubescent; flowers blue, 1 in. long, in large axillary racemes; legume oblong, 3–6-seeded. March–May. Introduced and cultivated for winter pastures.

XX. LATHYRUS.

Like *Vicia*, excepting that the style is bearded on the side toward the standard.

1. L. PUSILLUS Ell. DWARF VETCH. Annual; stem slender, erect or reclining, 10–15 in. long; leaves short-petioled; stipules sagittate; leaflets 2, linear or linear-lanceolate, smooth; peduncles longer than the leaves, 1–2-flowered; flowers purple; calyx teeth nearly equal; legume long and slender, 10–15-seeded. February–May. On sandy soil, common along fences.

2. L. VENOSUS Muhl. VEINY VETCH. Perennial; stem stout, prominently angled, climbing or reclining, 2–5 ft. long; leaves short-petioled; stipules large, lanceolate; leaflets 5–7 pairs, broadly ovate, obtuse, mucronate; peduncles nearly as long as the leaves, many-flowered; flowers purple, $\frac{3}{4}$ in. long; calyx teeth very unequal; pod linear, veined, 4–6-seeded. April–June. Shady banks.

XXI. BRADBURYA.

Perennial herbs; stems twining or prostrate; leaves 3-foliate; stipules persistent; flowers large, axillary, racemed or solitary; calyx short, 5-toothed, the two upper teeth partly united; standard large, erect, orbicular, emarginate, spurred on the back; stamens monadelphous below; style smooth; legume sessile, linear, many-seeded.

B. VIRGINIANA (L.) Kuntze. SPURRED BUTTERFLY PEA. Stem slender, much-branched, rough with hooked pubescence, 2–5 ft. long; leaflets ovate, acute at the apex, rounded at the base, reticulate-veined, stipellate, the upper one long-stalked; peduncles as long as the petioles, often in pairs, 1–4-flowered; flowers pink-purple, 1–1$\frac{1}{2}$ in. broad, short-pediceled; calyx lobes subulate; legume linear, curved, the margin thickened, many-seeded, 4–6 in. long. May–September. Common on dry, sandy soil.

XXII. CLITORIA.

Perennial herbs; leaves petioled, 3-foliate; stipules persistent; flowers large, on axillary peduncles; calyx tubular, 5-toothed, the two upper teeth partly united; standard large, erect, orbicular, emarginate, not spurred on the back, keel much shorter than the wings; stamens monadelphous below; style hairy; legume stipitate, flattened, few-seeded.

C. MARIANA L. BUTTERFLY PEA. Stem erect or twining, smooth, 1–3 ft. long; leaves short-petioled, stipules small; leaflets oblong-lanceolate, pale beneath, stipellate; peduncles shorter than the leaves, 1–3-flowered; flowers large, showy, pale purple, $1\frac{1}{2}$–2 in. long; legume 1–$1\frac{1}{2}$ in. long, $\frac{1}{4}$ in. wide, acute, 3–4-seeded. May–August. Dry, sandy soil.

XXIII. APIOS.

Perennial twining vines, producing tubers from underground shoots; leaves petioled, odd-pinnate; flowers in dense axillary racemes; calyx 2-lipped, the lateral teeth nearly obsolete; standard broad, reflexed, keel twisted; stamens diadelphous; legume linear, compressed, many-seeded.

A. APIOS (L.) MacM. GROUND-NUT. Stems twining high, juice milky, rootstocks bearing edible tubers; leaves short-petioled; stipules small, soon deciduous; leaflets 5–7, ovate to ovate-lanceolate, acute, slightly stipellate; raceme shorter than the leaves, densely many-flowered, often branching; flowers brownish-purple, about $\frac{1}{2}$ in. long; legume linear, slightly compressed, seeds black, separated by corky tissue. June–August. On damp soil.

XXIV. GALACTIA.

Perennial herbs; stems prostrate or climbing, juice often milky; leaves 3-foliate or pinnate, stipellate; flowers small, in axillary racemes; calyx 4-lobed, the upper lobe largest and about as long as the tube; standard oblong or obovate, reflexed; stamens diadelphous; ovary nearly sessile, style not bearded; legume linear, 2-valved, many-seeded.

1. G. REGULARIS (L.) B. S. P. Stems prostrate, minutely pubescent, branching, 2–3 ft. long; leaves longer than the petioles; leaf-

lets oval, rigid, smooth above, pubescent beneath, the upper one long-stalked; racemes shorter than the leaves, 3–6-flowered; flowers large, reddish-purple; style long; legume linear, curved, nearly smooth, 4–6-seeded. June–August. Dry pine barrens.

2. G. VOLUBILIS (L.) Britt. Stems twining or prostrate, much-branched, pubescent or nearly smooth, often several feet in length; leaflets thin, oval to linear-oblong, rounded or emarginate at both ends, smooth or slightly hairy above, paler and pubescent beneath; racemes slender, variable in length, often several times as long as the leaves, single or 2–3 from the same axil; flowers single, or 2–3 together, purplish, about $\frac{1}{2}$ in. long; legume linear, nearly straight, compressed, pubescent. June–July. On dry soil.

XXV. RHYNCHOSIA.

Perennial herbs; stems erect or twining; leaves 1–3-foliate; leaflets mostly resinous-dotted; flowers yellow, in dense axillary or terminal racemes or spikes; calyx 2-lipped, 4–5-toothed; standard orbicular or reniform, reflexed; stamens diadelphous; ovary sessile, style slender; legume short, 1–2-seeded.

1. R. MINIMA DC. CLIMBING RHYNCHOSIA. Stem twining, widely branched, tomentose, 3–6 ft. long; leaflets small, orbicular or rhombic, acute, rugose above, dotted beneath; racemes very slender, 2–3 times as long as the leaves; flowers scattered, minute, reflexed; legume strongly curved. May–July. Sandy soil, especially near the coast.

2. R. SIMPLICIFOLIA (Walt.) Wood. ROUND-LEAVED RHYNCHOSIA. Stem erect, rough, hairy, 3–8 in. high; leaves pubescent; stipules lanceolate; petioles about as long as the single, orbicular or reniform, erect, pubescent leaflet; racemes dense, often clustered; legume oblong, compressed, 1–2-seeded. April–June. On dry soil.

XXVI. PHASEOLUS.

Annual or perennial herbs; stems twining or prostrate; leaves trifoliate; flowers in axillary racemes or clusters; calyx 5-toothed, the two upper teeth somewhat united; standard orbicular, often recurved, keel spirally twisted; stamens diadelphous; legume linear or falcate, few–many-seeded.

P. POLYSTACHYUS (L.) B. S. P. WILD BEAN. Perennial; stem twining or trailing, branching, pubescent, 10–15 ft. long;

leaflets ovate, acute at the apex, rounded at the base, the terminal one long-stalked; stipules lanceolate, deciduous; racemes axillary, often branched, much longer than the leaves; flowers purple, scattered, pedicellate; legume stipitate, compressed, falcate, 2–3 in. long, 4–6-seeded. June–July. Low woods and thickets.

XXVII. STROPHOSTYLES.

Annual or perennial; stems twining or trailing; leaves 3-foliate, stipellate; flowers clustered at the summit of the axillary peduncles; calyx 5-toothed, the two upper teeth more or less united; standard orbicular, keel twisted; stamens diadelphous; pod linear, several-seeded, seeds scurfy or pubescent.

S. HELVOLA (L.) Britt. TRAILING BEAN. Annual or sometimes perennial; stem slender, trailing or twining, pubescent, 2–4 ft. long; leaflets extremely variable, from prominently 3-lobed to ovate or oblong-linear; peduncles 2–4 times as long as the leaves; flowers 4–8, sessile, greenish-purple; legume slender, terete, 4–8-seeded. June–September. Common in dry soil.

XXVIII. ERYTHRINA.

Shrubby or herbaceous; stems armed with prickles; leaves trifoliate; leaflets 3-lobed; flowers in long terminal racemes; calyx tubular, truncate and oblique at the throat; standard narrowly oblong, erect, wings and keel small; stamens and style exserted; legume stipitate, 2-valved, several-seeded.

E. HERBACEA L. CORAL PLANT. Perennial, from a very large woody root; stems erect, smooth, purple, 2–3 ft. high; flowering stems leafless except near the ground; leaves long-petioled; leaflets prominently 3-lobed or sometimes hastate, smooth, dark green, the terminal one long-stalked; racemes erect, 1–2 ft. long, many-flowered; flowers deep scarlet, 2 in. long; legume nodulose, opening by one suture, seeds bright scarlet. April–May. Light, sandy soil.

62. GERANIACEÆ. GERANIUM FAMILY.

Annual, biennial or perennial herbs with tumid joints; leaves alternate or opposite, simple, more or less lobed or

divided, stipulate; flowers perfect, regular or irregular; sepals 5, persistent; petals 5, deciduous; stamens 5, 10 or 15; ovary 1, compound, 5-celled, 1–2 ovules in each cell, styles 5, usually long and persistent, adherent to the elongated receptacle.

I. GERANIUM.

Annual, biennial or perennial herbs; leaves palmately lobed or divided, alternate or opposite, petioled; flowers regular; stamens 10, the alternate ones usually longer; ovary 5-celled, 5-seeded, the 5 cells of the ripened ovary separating elastically from the elongated central axis.

1. G. MACULATUM L. WILD CRANE'S-BILL. Perennial, from a thickened and tuberous rootstock; stems erect, simple or branched, hairy, 1–2 ft. high; leaves palmately 3–7-parted, the lobes incised or toothed, the lower long-petioled, the upper nearly sessile; peduncles long and slender, usually with a pair of leaves at the base of the few-flowered umbel; flowers pink-purple, 1–1½ in. broad; sepals hairy and awn-pointed; petals entire, pubescent at the base; seeds reticulated. April–May. In damp, open woods.

2. G. CAROLINIANUM L. CAROLINA CRANE'S-BILL. Annual; stem decumbent or erect, pubescent; leaves palmately 3–7-parted, the divisions narrow, toothed, and cut; peduncles short, 2-flowered; flowers pink-purple or nearly white, about ½ in. broad; sepals pubescent, about as long as the emarginate petals; seeds finely reticulated and pubescent. March–April. Common in waste places.

II. PELARGONIUM.

Perennial herbs; stems sometimes woody at the base, and somewhat fleshy above; flowers irregular; sepals 5, the upper one with a slender, nectariferous tube decurrent on the pedicel; petals 5, the two lower ones smaller; stamens 10, 3 or 5 of them sterile. A South African genus of which there are several species and many varieties in cultivation, all known by the general name "Geranium."

1. P. ZONALE L'Hérit. HORSE-SHOE GERANIUM. Stem erect, widely branched, woody below; leaves alternate, opposite or sometimes in 3's, orbicular or reniform, palmately veined, crenate, pubes-

cent, usually with a dark zone near the middle; flowers in a long peduncled umbel, showy, red or white, often double. Numberless varieties in cultivation.

2. P. GRAVEOLENS L'Hérit. ROSE GERANIUM. Stem erect or ascending, densely pubescent, 1–3 ft. high; leaves alternate, palmately lobed or divided, the lobes often finely dissected, revolute at the edges; flowers umbelled, small, light purple with darker veins; whole plant very fragrant. Common in cultivation.

63. OXALIDACEÆ. SORREL FAMILY.

Low annual or perennial herbs, with acid juice, root often bulbous; leaves petioled, trifoliate; flowers perfect, regular; sepals 5, persistent; petals 5, deciduous; stamens 10, monadelphous at the base, the alternate ones longer; ovary 5-celled, several-seeded, styles distinct.

OXALIS.

Characters of the family.

1. O. VIOLACEA L. VIOLET WOOD-SORREL. Perennial, from a bulbous root, acaulescent; leaves long-petioled, leaflets obcordate, sometimes slightly pubescent, often with a dark zone near the middle; scapes usually longer than the petioles, umbellately 4–10-flowered, pedicels slender; flowers violet-purple, nodding; petals obtuse, 2–3 times as long as the sepals; scapes and petioles 4–5 in. long. May–June. Common in rich woods.

2. O. STRICTA L. YELLOW WOOD-SORREL. Annual or perennial; stem slender, decumbent or ascending, branching, 3–12 in. long, pubescent with long hairs; leaves slender, petioled, leaflets broadly obcordate, sensitive; flowers yellow, in small cymes or umbellate clusters on axillary peduncles longer than the petioles; capsule erect, cylindrical, dehiscence loculicidal, often throwing the transversely ridged seeds to a considerable distance. March–December. Common in waste places.

64. RUTACEÆ. RUE FAMILY.

Shrubs or trees; leaves alternate, compound, exstipulate, punctate; flowers perfect or variously imperfect; sepals and

petals 3–5 or none; petals hypogynous or perigynous when present; stamens as many or twice as many as the sepals, inserted on the glandular disk; pistils 2–5, often partially united; fruit a capsule or a samara.

I. XANTHOXYLUM.

Trees or shrubs; bark, twigs, and petioles usually prickly; leaves odd-pinnate, punctate with pellucid dots; flowers in axillary or terminal cymes, monœcious or diœcious; sepals and petals 3–5 or none; stamens 3–5, hypogynous; pistils 2–5, distinct, sessile or stipitate; carpels 2-valved, 1–2-seeded; seeds smooth and shining.

1. X. Pterota HBK. Bastard Ironwood. A shrub or small tree; branches crooked and armed with curved, stipular prickles or sometimes smooth; leaflets 7–11, sessile, obovate, somewhat crenate, dots few, rachis and petiole winged; flowers in axillary, sessile or short-peduncled clusters; sepals, petals, and stamens 4; ovaries 2; carpels globose, dotted, stipitate. May–June. On rich soil, more common southward.

2. X. Clava-Herculis L. Hercules's Club. A tree 20–40 ft. high; bark very prickly; prickles on the older parts often surrounded by a ring of cork; leaflets 9–21, ovate-lanceolate, acuminate, crenate, inequilateral, shining above; cymes terminal, appearing before the leaves; flowers small, greenish; sepals and petals 4–5; capsules 2–3, sessile. May–June. In rich, moist woods.

II. PTELEA.

Shrubs with smooth and bitter bark; leaves trifoliate; flowers in terminal cymes, polygamous; sepals 3–6, deciduous, much shorter than the petals; stamens 4–5, longer than the petals and alternate with them; pistillate flowers producing abortive stamens; ovary compressed, 2-celled; fruit a 2-celled, 2-seeded, broadly winged samara.

P. trifoliata L. Hop-tree. A shrub 4–8 ft. high; leaves long-petioled, leaflets oval or ovate, acute, obscurely serrate, the lateral ones oblique; cymes compound; flowers greenish; stamens mostly 4, filaments villous; samara about 1 in. in diameter, wing emarginate, strongly reticulated. May–June. Rocky banks.

65. SIMARUBACEÆ. AILANTHUS FAMILY.

Trees or shrubs, bark bitter, juice milky; leaves alternate, pinnately compound, stipules none; leaflets not dotted; flowers in large, axillary or terminal panicles, regular, diœcious or polygamous; calyx 4–5-toothed or parted, persistent; petals 4–5, deciduous; stamens twice as many as the sepals, hypogynous; ovary of 4–5 distinct or united, 1-seeded carpels; fruit a samara.

AILANTHUS.

Trees, bark brown, nearly smooth; leaves odd-pinnate; flowers in dense terminal panicles, greenish-white, polygamous or diœcious; sepals and petals 5; staminate flowers with 10 stamens; pistillate flowers often bearing 2–3 stamens; ovary deeply 2–5-cleft or divided, ovules solitary; samara oblong.

A. GLANDULOSA Desf. TREE OF HEAVEN. Trees, sometimes 60–80 ft. high; leaves odd-pinnate, often 2–3 ft. long; leaflets many, usually opposite, ovate-lanceolate, acuminate at the apex, truncate, oblique and usually glandular-toothed at the base, entire; flowers about $\frac{1}{4}$ in. broad, the staminate disagreeably odorous; samaras with oblong wings, 1 in. long. May–June. Introduced from China, and naturalized in many places.

66. MELIACEÆ. MELIA FAMILY.

Trees; leaves alternate, exstipulate, pinnately decompound; flowers perfect, in axillary panicles; sepals 5, short, obtuse; petals 5, 2–3 times as long as the sepals, oblong, obtuse; stamens 10, monadelphous; ovary 5-celled, 10-ovuled; fruit a 5-celled, 5-seeded nut enclosed in a fleshy covering.

MELIA.

Characters of the family.

M. AZEDERACH L. UMBRELLA TREE. Trees of medium size with a dense hemispherical head; leaves bipinnate; leaflets ovate,

acuminate at the apex, rounded at the base, irregularly serrate, glabrous; flowers in large, compound panicles, fragrant, lilac-colored; sepals linear-spatulate, united at the base; petals united below, spreading above; fruit fleshy, enclosing a bony 5-celled nut with one seed in each cell, persistent through the winter. April–May. Introduced from China; common in cultivation.

67. POLYGALACEÆ. MILKWORT FAMILY.

Herbs, or rarely shrubs; leaves simple, alternate, opposite or verticillate, exstipulate; pedicels bracted; flowers mostly in spikes or racemes, but sometimes solitary, with a general resemblance to those of the Pea family; sepals 5, persistent, the two lateral longer and wing-like; petals 3, somewhat united, the middle one longer, usually crested and forming a keel, sometimes with 2 additional scale-like petals; stamens 4–8, monadelphous or diadelphous; ovary superior, compound; fruit a 2-seeded capsule, seeds usually caruneulate and hairy.

POLYGALA.

Annual, biennial or perennial herbs; leaves alternate, opposite or verticillate, usually small and narrow; flowers usually spiked or racemed, but sometimes solitary, and occasionally on subterranean branches; stamens 8 or sometimes 6, somewhat united with the petals, usually monadelphous; style simple, curved, club-shaped; capsule 2-celled, 2-seeded, seeds caruneulate and hairy.

1. P. RAMOSA Ell. LOW YELLOW MILKWORT. Biennial; stems single or tufted, erect, simple, 6–12 in. high; leaves alternate, basal leaves spatulate to obovate, obtuse; stem leaves linear-oblong, acute, numerous, somewhat fleshy; flowers bright yellow, in corymbose spikes, wings oblong, acute, crest minute; seeds small, oval, hairy, at least twice the length of the caruncle; plant turning greenish-black in drying. June–September. Open pine barrens.

2. P. LUTEA L. ORANGE MILKWORT. Biennial; stem simple or occasionally branched, erect, glabrous, 6–12 in. high; leaves alternate, root leaves spatulate, obtuse, stem leaves oblanceolate, acute; spikes solitary, terminal, oblong, dense; flowers orange-yellow, wings

elliptical or ovate, acute, crest minute; seeds obovate, sparsely hairy, a little longer than the lobes of the caruncle. May–August. Moist woods.

3. P. INCARNATA L. PINK MILKWORT. Annual; stem simple or rarely branched, erect, glaucous, 12–18 in. high; leaves few, alternate, fleshy, linear, sometimes small and scale-like; spike terminal, solitary, slender, densely flowered; flowers pink; petals united into a tube twice the length of the elliptical wings, crest conspicuous; seeds oval, hairy, caruncle spongy. May–August. Dry soil in open fields.

4. P. GRANDIFLORA Walt. SHOWY MILKWORT. Perennial or biennial; stems erect or ascending, branched, 6–12 in. high; leaves alternate, elliptical, pubescent; flowers in long terminal and axillary racemes, large, pink or purple, wings large, orbicular, pedicels drooping; seeds oblong, hairy, caruncle small. May-September. Dry, sandy soil.

5. P. POLYGAMA Walt. RACEMED MILKWORT. Biennial; stems erect, simple, numerous, smooth, very leafy; leaves elliptical or the lower spatulate; flowers of two kinds, the showy and perfect purple flowers in loose terminal racemes, and the subterranean inconspicuous but fertile flowers; seeds oblong or ovate, very hairy, twice the length of the caruncle. April-June. Wet pine barrens.

68. EUPHORBIACEÆ. SPURGE FAMILY.

Trees, shrubs or herbs, with an acrid, and usually milky juice; leaves alternate, opposite or verticillate, petioled or sessile, stipulate or exstipulate; flowers various, often monœcious, petaloid or enclosed in a petal-like involucre; stamens few or many; styles usually 3, simple or much-divided; ovary usually 3-celled, sometimes 2-celled, with 2 ovules suspended in each cell, the carpels at length separating from the central axis.

I. RICINUS.

Annual herbs, shrubs or trees; leaves alternate, simple, petioled, palmately lobed; flowers monœcious, in a large oblong spike or panicle, the pistillate flowers at the summit; calyx 3–5-parted; petals wanting; stamens numerous, filaments branched; style short, stigmas 3, 2-parted; capsule spiny, 3-celled, 3-seeded.

R. COMMUNIS L. CASTOR BEAN. Annual, becoming a tree in the tropics; stem smooth and glaucous, 6–12 ft. high; leaves large, often 1 ft. broad, peltate, palmately 6–12-lobed, the lobes lanceolate, irregularly toothed, petioles long, glandular: stipules large, deciduous; panicles in the forks of the stem, dense; capsules very spiny, $\frac{1}{2}$–$\frac{3}{4}$ in. long; seeds oval, smooth, mottled. June–October. Introduced from India.

II. JATROPHA.

Shrubs or herbs; leaves alternate; flowers monœcious, staminate and pistillate intermixed in the cymes, apetalous: calyx large, white, 5-lobed, corolla-like; stamens numerous, usually monadelphous; ovary usually 3-celled, 3-seeded, styles 3, united at the base, several-parted.

J. STIMULOSA Michx. SPURGE NETTLE. Perennial herbs armed with stinging hairs; stems erect, branched, bright green with white lines, 8–15 in. high; leaves long-petioled, deeply palmately 3–5-lobed, the lobes irregularly cut and toothed, often mottled; sepals white, spreading; seeds oblong, smooth, mottled. April–September. In dry woods.

III. EUPHORBIA.

Herbs with milky juice; inflorescence cymose; flowers monœcious, without calyx or corolla, usually 1 pistillate and several monandrous staminate flowers are surrounded by cup-like involucre resembling a corolla, and often gland-bearing between its 4–5 lobes; styles 3, each 2-cleft; capsule stipitate, 3-celled, 3-seeded.

1. E. MACULATA L. SPOTTED SPURGE. Annual; stem prostrate, widely branched, pubescent, 4–12 in. long; leaves opposite, stipulate, short-petioled, oblong, oblique at the base, serrate, usually blotched with purple; involucres small, and mostly near the ends of the branches; glands 4, cup-shaped, their appendages white; capsule ovoid, pubescent, seed 4-angled, faintly wrinkled and pitted. June–October. Very common in waste places.

2. E. COROLLATA L. FLOWERING SPURGE. Perennial; stem erect, umbellately branched above, smooth or pubescent, 1–3 ft. high; leaves of the stem alternate, those of the branches usually opposite or whorled, rather thick, oval to narrowly oblong, pale beneath, usually slightly pubescent; flowering branches repeatedly forked; involucres terminal and in the forks of the branches, pedun-

cled; glands 1–5, oblong, green; appendages white and petal-like, showy; capsule erect, seed smooth or faintly pitted. April–November. Common in dry, open woods.

69. ANACARDIACEÆ. SUMAC FAMILY.

Trees or shrubs with resinous, acrid or milky sap; leaves simple, trifoliate or pinnately compound, alternate, exstipulate; flowers perfect or imperfect, small; calyx 3–5-parted, persistent; petals 3–5 or wanting; stamens as many as the sepals or sometimes twice as many, inserted in the base of the calyx, distinct; ovary free, 1-celled, styles 1–3; fruit a 1-seeded drupe.

I. RHUS.

Trees or shrubs; leaves trifoliate or odd-pinnate; flowers in spikes or panicles; calyx mostly 5-parted; petals and stamens 5; pistil 1, sessile, styles 3, terminal; drupe small, smooth or pubescent.

1. R. COPALLINA L. SUMAC. A shrub or small tree, sometimes 25–30 ft. high; branches tomentose; leaves odd-pinnate, rachis pubescent and wing-margined; leaflets 9–21, ovate-lanceolate, acute at the apex, inequilateral, entire or slightly toothed, smooth and green above, pale and pubescent beneath; panicle often large and spreading; flowers polygamous; drupe red, hairy, acid. June–August. Open woods.

2. R. HIRTA (L.) Sudw. STAGHORN SUMAC. A small tree, 20–40 ft. high; branches and petioles villous; leaves odd-pinnate, leaflets 17–27, lanceolate-oblong, acuminate at the apex, very obtuse at the base, sharply serrate, smooth above, pale and pubescent beneath; flowers polygamous, in dense terminal panicles; drupes red, with crimson hairs. June–July. Dry hillsides.

3. R. AROMATICA Ait. FRAGRANT SUMAC. A branching shrub, 2–5 ft. high; leaves trifoliate, pubescent when young, smooth when old; leaflets ovate or the terminal one obovate, larger and somewhat 3-lobed or crenate; flowers diœcious, in single or clustered terminal spikes 1 in. or more in length, appearing before the leaves; drupe red, hairy. March–April. Dry, open woods.

4. R. RADICANS L. POISON VINE. Stem a woody vine climbing high by aërial rootlets, or sometimes short and erect; leaves

petioled, trifoliate, pubescent; leaflets ovate or oval, acuminate, entire or somewhat dentate, often angled or lobed; flowers diœcious, in loose axillary panicles; drupe nearly white, smooth. May–June. Common in open woods and along fences. Plant poisonous to the touch.

II. COTINUS.

Shrubs or small trees; leaves simple; flowers in large terminal panicles; calyx 5-parted; petals 5, longer than the sepals; stamens 5; styles 3, lateral; drupe ovoid, inequilateral.

C. COTINOIDES (Nutt.) Britt. SMOKE TREE. A small tree; leaves oval or obovate, obtuse at the apex, acute at the base, entire, glabrous or slightly pubescent; flowers in loose and spreading panicles, many of the pedicels abortive but becoming elongated and very plumose; flowers small, perfect; drupe smooth. May–June. Often cultivated for ornament.

70. CYRILLACEÆ. CYRILLA FAMILY.

Small trees or shrubs; leaves often evergreen, alternate; stipules none; flowers perfect, in terminal and lateral racemes; sepals 4–8, persistent; petals as many as the sepals, hypogynous; stamens 5–10, distinct; ovary 2–5-celled, 2–5-ovuled, style entire or 2–4-lobed; fruit dry, 1–5-seeded.

I. CYRILLA.

Small trees; branches glabrous; leaves entire, short-petioled; flowers white, in racemes clustered at the base of the growth of the season; sepals 5, small; petals 5, spreading, deciduous, longer than the sepals; stamens 5, alternate with the petals; style persistent, 2-lobed; fruit 2-celled, 2-seeded.

C. RACEMIFLORA Walt. LEATHERWOOD. A shrub, 10–15 ft. high; branches often in whorls; leaves elliptical or ovate-oblong, smooth, entire; racemes many-flowered, 4–6 in. long, pedicels bracted; fruit ovate, about $\frac{1}{12}$ in. long, tipped with the persistent style. June–July. Common on damp soil.

II. CLIFTONIA.

Small trees or shrubs; branches smooth; leaves evergreen, entire, glaucous; flowers white, racemose; sepals 5–8, minute; petals 5–8, spreading; stamens 10, those opposite the petals longer; stigma sessile, 3–4-lobed; fruit 3–4-winged, 3–4-celled, cells 1-seeded.

C. LIGUSTRINA Banks. TITI. A small tree; leaves obovate or oblong, glaucous, thick; racemes terminal, 2–4 in. long, many-flowered; flowers white, fragrant; fruit nodding, long-persistent. March–April On damp soil, more abundant southward.

71. ILICACEÆ. HOLLY FAMILY.

Trees or shrubs; leaves simple, alternate, petioled; stipules small or wanting; flowers small, greenish, clustered or solitary in the axils, usually diœcious; calyx 4–9-parted; petals 4–9, somewhat united at the base; stamens inserted in the tube of the corolla and alternate with its lobes; ovary free, 4–9-celled, with a single ovule in each cell; fruit a berry-like drupe, 4–9-seeded.

ILEX.

Small trees or shrubs; leaves usually coriaceous, often persistent and evergreen; stipules minute; flowers axillary, 4–9-parted, the fertile often solitary and the staminate clustered; fruit a drupe with 4–9 nutlets.

1. I. OPACA Ait. HOLLY. Trees with smooth, light-colored bark, and hard, very white wood; young twigs pubescent; leaves coriaceous, oval or ovate, margin prickly toothed, dark green and shining above, paler and sometimes slightly puberulent beneath; peduncles short, bracted; flowers 4-parted, staminate flowers in small cymes, the pistillate usually solitary; drupes bright red. April–May. Damp, sandy soil.

2. I. DECIDUA Walt. DECIDUOUS HOLLY. Small trees; twigs smooth; leaves thin, obovate, obtuse or sometimes acute at the apex, crenate, smooth, deciduous; flowers in sessile clusters, 4–6-parted; drupes very numerous, bright red. April–May. On low ground.

72. CELASTRACEÆ. STAFF-TREE FAMILY.

Shrubs, sometimes climbing; leaves simple, alternate or opposite, stipulate; flowers small, regular, perfect; calyx 4–5-parted, persistent; petals 4–5; stamens 4–5, alternate with the petals and inserted with them on the disk; ovary 1, carpels 2–5, styles exserted; fruit a 2–5-celled pod, seeds ariled.

EUONYMUS.

Shrubs with 4-angled branches; leaves opposite; flowers in axillary, peduncled cymes, purplish or greenish, small; sepals and petals 4–5, spreading; stamens as many as the petals, short; ovary 3–5-celled, with 2 ovules in each cell; seeds enclosed in a red, fleshy aril.

1. E. Americanus L. Strawberry Bush. A shrub 3–8 ft. high; leaves short-petioled, ovate to ovate-lanceolate, acute or acuminate at the apex, finely serrulate, smooth or slightly hairy; peduncles axillary, slender, 1–3-flowered; flowers greenish; capsule 3–5-angled, warty. May–June. In low, shady woods.

2. E. atropurpureus Jacq. Wahoo. A tree-like shrub 10–15 ft. high; leaves oval to ovate, acuminate, finely serrulate, puberulent, petioles $\frac{1}{2}$–$\frac{3}{4}$ in. long; peduncles slender, 3-forked, several flowered; flower purplish; capsule deeply 3–4-lobed, smooth. May–June. River banks.

73. ACERACEÆ. MAPLE FAMILY.

Trees or shrubs, with watery, often saccharine sap; leaves opposite, simple and palmately lobed, or pinnate, exstipulate; flowers regular, mostly polygamous or diœcious, in axillary and terminal cymes or racemes; calyx 4–9-parted; petals as many as the lobes of the calyx or none; stamens 4–12, hypogynous; ovary 2-celled, styles 2; fruit a double samara.

ACER.

Characters of the family.

1. A. RUBRUM L. RED MAPLE. A small tree with red or purple twigs; leaves simple, broadly ovate, palmately 3–5-lobed or sometimes merely serrate or cut-toothed, acuminate at the apex, rounded or cordate at the base, smooth or pubescent, becoming bright red in autumn; flowers appearing before the leaves on erect, clustered pedicels; petals red or yellow, oblong or linear; fruiting pedicels elongated and drooping; samara red, smooth, wings about an inch long. February–April. Swamps and river banks.

2. A. SACCHARUM Marsh. SUGAR MAPLE. A large tree; leaves simple, palmately lobed, truncate or cordate at the base, lobes sinuate-toothed and acuminate, pale and slightly pubescent beneath; flowers appearing with the leaves, on clustered, drooping pedicels; calyx bell-shaped, fringed; petals none; samaras smooth, wings about 1–1½ in. long. April–May. In cold woods, more abundant northward. The sap of this tree is the principal source of maple sugar, and some forms of the tree produce the curled maple and bird's-eye maple used in cabinet making.

3. A. NEGUNDO L. BOX ELDER. A small tree; leaves opposite, pinnately 3–5-foliate; leaflets ovate, lobed, toothed or entire, pubescent when young; flowers diœcious, appearing from lateral buds before or with the leaves; the staminate on long and drooping pedicels, the pistillate in drooping racemes; samaras smooth, 1–1½ in. long. March-April. River banks. Often cultivated as a quick-growing shade tree.

74. HIPPOCASTANACEÆ. BUCKEYE FAMILY.

Trees or shrubs; leaves opposite, long-petioled, palmately compound; flowers showy, polygamous, in terminal panicles; calyx 5-lobed, oblique; petals 4–5, unequal; stamens 5–8, hypogynous; pistil 1, ovary 3-celled, 2 ovules in each cell, style slender; fruit a 1–3-celled, leathery capsule, 1–3-seeded, seeds with a large scar.

ÆSCULUS.

Characters of the family.

Æ. PAVIA L. RED BUCKEYE. Shrubs; stems erect, branched, 4–8 ft. high; leaflets usually 5, lanceolate to narrowly oval, acumi-

nate at both ends, finely serrate, smooth or nearly so; flowers in dense, erect panicles, bright red; stamens rather longer than the petals; fruit nearly smooth. March–May. Common in open woods.

75. RHAMNACEÆ. BUCKTHORN FAMILY.

Trees, shrubs or woody vines; stem often thorny; leaves simple, alternate or opposite, stipulate; flowers mostly in axillary or terminal cymes or panicles, small, greenish, perfect or polygamous; calyx 4–5-parted; petals hooded, alternate with the sepals or wanting; stamens as many as the sepals and opposite them, perigynous; style 1, ovary 1–4-celled with a single ovule in each cell; fruit a drupe or capsule.

I. BERCHEMIA.

Shrubs; stems twining or erect; leaves alternate, prominently pinnate-veined, stipules minute; flowers in axillary or terminal panicles, or rarely solitary; calyx tube hemispherical, 5-lobed; petals 5, sessile, concave, as long as the calyx; ovary 2-celled, half-inferior, stigmas 2; fruit an oval, 2-seeded drupe.

B. SCANDENS (Hill) Trel. SUPPLE-JACK, RATTAN-VINE. A woody vine, often twining high; older bark yellowish, twigs purple, wood very tough; leaves ovate or oval, acute or obtuse, cuspidate at the apex, rounded at the base, wavy on the margins, green above, pale beneath; flowers in small panicles; drupe purple. May–June. In moist woods and along streams.

II. RHAMNUS.

Shrubs or small trees; leaves alternate; flowers in axillary cymes or panicles, perfect, polygamous or diœcious; calyx tube urn-shaped, 4–5-cleft; petals small, often wanting; ovary superior, 3–4-celled, style 3–4-parted; fruit a globose, berry-like drupe with 2–4 smooth or grooved nutlets.

R. CAROLINIANA Walt. CAROLINA BUCKTHORN. A small tree with black bark and very hard wood; twigs puberulent; leaves

alternate, prominently veined, elliptical to broadly oval, entire or obscurely serrate, smooth or sometimes pubescent below; petioles slender, pubescent; flowers in axillary, peduncled umbels; petals minute; drupe globose, $\frac{1}{3}$–$\frac{1}{2}$ in. in diameter, 3-seeded, seeds smooth. May–June. On river banks.

76. VITACEÆ. GRAPE FAMILY.

Climbing woody vines or diffuse shrubs; stems with joints distinct and enlarged; leaves simple or compound, petioled, stipulate; flowers perfect, greenish, polygamous or diœcious, in cymes, panicles or racemes; calyx minute, usually truncate; petals 4–5, distinct or united; stamens 4–5, opposite the petals, hypogynous or perigynous; ovary 1, usually more or less immersed in the disk, 2–6-celled, with 2 ovules in each cell, style short or none, stigma 2-lobed; fruit a 1–6-seeded berry.

I. VITIS.

Climbing woody vines; stems with tumid joints, climbing by tendrils opposite some of the leaves; leaves simple, palmately veined or lobed; stipules small, soon deciduous; flowers mostly polygamous or diœcious; petals often united at the apex and not expanding; stamens inserted between the lobes of the disk; ovary usually 2-celled, 4-ovuled; fruit juicy, 1–4-seeded.

1. V. Labrusca L. Fox Grape. Stems climbing high, often 1 ft. or more in diameter; bark shreddy, coming off in long strips, young branches woolly; leaves broadly cordate, more or less deeply 3–5-lobed, mucronate-dentate, very woolly when young, becoming smooth above; panicles of pistillate flowers compact, of staminate flowers looser; fruit about $\frac{1}{2}$ in. in diameter, dark purple or sometimes nearly white. April–May. In rich woods. Many of the cultivated varieties, Concord, Niagara, etc., have been developed from this species.

2. V. aestivalis Michx. Summer Grape. Stem climbing high; bark shreddy; leaves broadly cordate, 3–5-lobed, the lobes dentate, sinuses rounded, white-woolly when young, often nearly smooth when old; tendrils or panicles opposite 2 out of every 3

leaves, panicles long and slender; fruit dark blue, small, very acid. April–May. In rich woods.

3. V. ROTUNDIFOLIA Michx. MUSCADINE GRAPE. Stem climbing high; joints short; bark not shreddy, wood very hard, often producing long, aërial roots; leaves orbicular, cordate at the base, coarsely dentate, nearly or quite smooth; panicle small; fruit few in a cluster, large. May–June. The original form of the Scuppernong grape.

II. AMPELOPSIS.

Climbing or diffuse woody plants; leaves simple or pinnately compound; flowers in long-peduncled cymes, polygamous or diœcious; petals 5, distinct, deciduous; stamens as many as the petals and opposite them, inserted on the 5-lobed disk; ovary 2-celled, 2 ovules in each cell; fruit a berry, not edible.

A. ARBOREA (L.) Rusby. PEPPER-VINE. Stem diffuse, tendrils often none; leaves bi-pinnate; leaflets small, ovate, irregularly lobed or toothed, nearly or quite smooth; cymes opposite the leaves, forking; berry small, black. May–July. Common on margins of streams.

III. PARTHENOCISSUS.

Woody vines, climbing by tendrils and rootlets; leaves palmately compound; flowers in compound cymes, perfect or polygamous; petals 5, distinct, spreading, disk none; stamens 5; ovary 2-celled, 4-ovuled; fruit a 1–4-seeded berry, not edible.

P. QUINQUEFOLIA (L.) Planch. VIRGINIA CREEPER. Stem usually climbing high, but sometimes short and prostrate, often producing many adventitious aërial roots which assist the vine in holding to a support; tendrils usually terminating in flat, adhesive disks; leaves palmately 5-foliate; leaflets oval, coarsely and unevenly toothed above, usually entire below, smooth or slightly pubescent; cymes large and spreading when mature; pedicels red; berries small, dark blue. May–June. Common in rich woods.

77. TILIACEÆ. LINDEN FAMILY.

Trees or rarely herbs; leaves simple, alternate; stipules deciduous; flowers in axillary or terminal cymes or panicles, perfect; sepals usually 5, deciduous; petals 5 or less; stamens many, distinct or united in several groups; style 1, stigma 4–10-lobed; capsule 2–5-celled, 1–many-seeded.

TILIA.

Trees with rough, gray bark on the trunk, bark of the twigs smooth, lead-colored; wood white and soft; leaves cordate, usually inequilateral; cymes axillary or terminal, peduncle adnate to a large, prominently veined bract; flowers yellowish-white; sepals 5; petals 5; stamens many, in 5 groups; ovary 5-celled with 2 ovules in each cell, stigma 5-lobed; capsule 1-celled, 1–2-seeded; peduncle and bract deciduous with the matured fruit, the bract forming a wing by which the fruit is often carried to a considerable distance.

T. PUBESCENS Ait. BASSWOOD. A tree of medium size; leaves ovate, acuminate at the apex, obtuse and oblique at the base, mucronate-serrate, woolly on both sides or smooth above when old; flowers fragrant, floral bract 2–3 in. long; fruit about ¼ in. in diameter. May–June. In rich woods. Bees gather large quantities of nectar from the flowers.

78. MALVACEÆ. MALLOWS FAMILY.

Shrubs or herbs with mucilaginous juice; leaves simple, alternate, stipulate, palmately veined, usually with stellate pubescence; flowers mostly axillary, on jointed peduncles, perfect, regular, often with a calyx-like involucre; sepals 5, united at the base; petals 5, strongly convolute in the bud; stamens many, inserted in the base of the petals and united into a tube surrounding the pistil; styles distinct or united, ovary several-celled; fruit a several-celled dehiscent pod, or a number of separate 1-seeded carpels, united around a central axis.

I. ALTHÆA.

Biennial or perennial herbs; stems erect, hairy or pubescent; flowers nearly sessile, involucre of 6-9 bracts; anthers at the top of the column; styles many; carpels many, 1-seeded, indehiscent, separating from the axis at maturity.

A. ROSEA Cav. HOLLYHOCK. Biennial; stem erect, 3–6 ft. high, hairy; leaves cordate, 5–7-angled, the lobes irregularly toothed, rugose; flowers large, sessile, white or colored, often double. Summer. Cultivated and often spontaneous.

II. MALVA.

Annual, biennial or perennial herbs; stems smooth or hairy, erect or procumbent; involucel 3-leaved, persistent; flowers peduncled; petals obcordate; anthers at the top of the column; styles many; carpels numerous, 1-seeded, indehiscent.

M. ROTUNDIFOLIA L. CHEESES. Stem annual or perennial, procumbent; leaves long-petioled, round-cordate or reniform, crenate or crenately lobed; flowers single or clustered; petals white with purple veins, about twice the length of the calyx lobes; styles 10–20; carpels broadly reniform, not beaked, pubescent. May–November. Common around dwellings.

III. CALLIRRHOË.

Perennial herbs; stem erect, ascending or procumbent; leaves long-petioled, lobed or divided: involucel 1–3-leaved, persistent, or none; flowers perfect; calyx deeply cleft; petals wedge-shaped, entire or crenate at the apex; anthers at the top of the stamen tube; styles many; carpels numerous, 1-seeded, beaked at the apex.

C. PAPAVER (Cav.) Gray. POPPY MALLOW. Stem simple or branched above, erect, rough-pubescent, 12–18 in. high; leaves 3–5-parted, the lobes oblong or lanceolate, irregularly toothed; involucel 1–3-leaved or none; flowers axillary, solitary, on peduncles sometimes 1 ft. long, purple, 1½–2 in. wide; petals finely crenate at the apex. May–September. Rich, open woods.

IV. SIDA.

Annual or perennial herbs; stem branching, erect or decumbent; leaves mostly undivided; involucel none; flowers small, axillary; calyx angular; anthers at the top of the column; styles 5–15; carpels as many as the styles, mostly 2-valved and 2-beaked, separating from each other at maturity, seed 3-angled.

1. S. SPINOSA L. PRICKLY SIDA. Annual; stem erect, widely branched above, 12–18 in. high; leaves petioled, ovate or oblong, usually acute at the apex and rounded at the base, serrate, slightly pubescent, lower leaves often cordate; petiole often with a tubercular spine at the base; stipules slender, half the length of the petiole; flowers single or clustered, yellow, $\frac{1}{2}$ in. wide; peduncles shorter than the petioles; carpels faintly reticulated. June-September. Common in waste places.

2. S. ELLIOTTII T. & G. ELLIOTT'S SIDA. Perennial; stem erect, slender, with straight branches, rough, 1–4 ft. high; leaves on short petioles, linear-oblong or elliptical, serrate, nearly smooth; stipules setaceous; flowers axillary, yellow, $\frac{3}{4}$–1 in. broad; peduncles longer than the petioles; carpels slightly beaked, strongly reticulated. June–October. Open woods.

V. ABUTILON.

Herbs or shrubs; stem erect, branched, usually softly pubescent; leaves long-petioled, cordate or angled; involucel none; flowers axillary; anthers at the top of the tube; ovaries 5 or more, 1-celled, several-seeded; carpels 2-valved, 2-beaked, finally separating from each other and from the central axis.

1. A. ABUTILON (L.) Rusby. VELVET LEAF. Annual; stem erect, branched above, velvety-pubescent, 2–5 ft. high; leaves cordate, acuminate at the apex, dentate or nearly entire, the blade about as long as the petiole; peduncles axillary, shorter than the petioles, 1–3-flowered; flowers yellow; carpels 12–15, strongly spinose-beaked, pubescent, somewhat inflated, 3-seeded. May–September. Introduced from China. Common in fields and waste places.

2. A. STRIATUM L. ABUTILON. An erect or spreading shrub 1–4 ft. high; leaves long-petioled, angulate-lobed, acuminate at the apex, crenate, smooth on both sides; peduncles longer than the petioles;

flowers drooping, red, yellow or white; petals strongly veined; stamen-tube and styles long exserted. A common garden and greenhouse shrub.

VI. MODIOLA.

Annual or biennial; stems prostrate, diffuse, often rooting at the joints; leaves cleft or divided; flowers axillary, peduncled, red; involucel 3-leaved, persistent; anthers at the top of the column; carpels 15-20, transversely 2-celled, with 1 ovule in each cell, beak spine-like, the carpels finally separating from each other and from the axis.

M. Caroliniana Don. Bristly Mallow. Stem pubescent or hirsute, widely branched, 1-2 ft. long; leaves long-petioled, deeply 5-7-parted, the divisions lobed or toothed; peduncles finally becoming longer than the petioles; petals about the length of the sepals; carpels hispid and prickly along the back. June-September. Waste places.

VII. HIBISCUS.

Herbs or shrubs; stem erect; leaves dentate, lobed or divided; involucel of many persistent bracts; flowers showy, on axillary peduncles; filaments united to form a 5-toothed tube which bears the anthers below the summit; stigmas 5; ovary 5-celled, many-seeded.

1. H. aculeatus Walt. Swamp Hibiscus. Perennial herbs; stems erect, rough-hispid, branched above, 3-6 ft. high; lower leaves cordate, 3-5-lobed, lobes toothed; upper leaves narrower and nearly entire; leaves of the involucel forked; flowers 3-4 in. wide, on short axillary peduncles; petals yellow with a purple base; capsule pubescent, seeds smooth. June-August. Margins of swamps.

2. H. militaris Cav. Halberd-leaved Mallow. Perennial; stem erect, smooth, 2-4 ft. high; leaves long-petioled, thin, acuminate at the apex, cordate at the base, crenate, many of the lower ones hastate-lobed; stipules deciduous; leaves of the involucel not forked; peduncles shorter than the petioles; flowers pale rose-color with a darker center, 2-3 in. long; calyx enlarged in fruit, enclosing the ovoid capsule, seeds silky. June-September. Along streams and on wet soil. [Among the cultivated plants belonging to this genus are H. Syriacus, the Shrubby Althea, and H. esculentus, the garden Okra. Cotton belongs to the nearly related genus Gossypium.]

79. THEACEÆ. TEA FAMILY.

Trees or shrubs; leaves alternate, simple, pinnately veined, exstipulate; flowers axillary or terminal, showy, perfect; sepals few or many, often unequal in size; petals 4–7 or more; stamens numerous, monadelphous below or in sets opposite the petals; styles 2–5, distinct or united; capsule 2–5-celled, 2–many ovules in each cell.

I. CAMELLIA.

Shrubs or small trees; leaves evergreen, often thick and coriaceous, smooth and shining; flowers axillary or terminal, short-peduncled; sepals many, the inner ones longer; petals white or colored, obovate; stamens many, monadelphous below; styles united, stigmas 3–5; fruit a dry, 3–5-celled capsule.

1. C. Japonica L. Camellia. Shrubs or small trees; leaves short-petioled, thick and leathery, dark green, shining, ovate, acuminate, serrate; flowers mostly terminal, solitary; petals red or white; stamens very numerous, often many of them transformed into petals. February–April. Introduced from Japan, and hardy in the southern section.

2. C. viridis. Tea. A branching shrub 2–6 ft. high; leaves petioled, lanceolate-oblong, acute, serrate, smooth and shining; flowers axillary, white, fragrant; petals twice as long as the sepals; capsule 2–5-celled, 2–5-seeded, seeds nearly black, as large as peas. March–June. Introduced from China and often cultivated.

II. STUARTIA.

Shrubs; leaves alternate, deciduous; flowers large, on short axillary peduncles; sepals 5–6, silky, lanceolate; petals 5–6, obovate, crenulate, silky; stamens monadelphous below, inserted in the base of the corolla; styles 1 or 5, ovary 5-celled, 2 ovules in each cell; fruit an ovoid, woody capsule.

S. Malachodendron L. Round-fruited Stuartia. Shrubs, 6–12 ft. high; twigs pubescent; leaves short-petioled, oval, thin, finely serrulate, slightly pubescent; flowers 2–3 in. wide, on very

short peduncles: sepals roundish, silky-pubescent, united below; petals white, minutely pubescent below, round-obovate; filaments purple; anthers blue; style single, 5-lobed; capsule globose, pubescent, seeds not margined. April–May. Shady woods.

80. HYPERICACEÆ. ST. JOHN'S-WORT FAMILY.

Herbs or shrubs; leaves simple, opposite, exstipulate, pellucid-punctate or black-dotted; flowers solitary or cymose; sepals 4–5, persistent, often unequal; petals 4–5, deciduous, usually oblique; stamens hypogynous, mostly numerous, often united at the base into 3 or 5 sets; styles 1–several, distinct or united; capsule 1-celled with parietal placentæ, or several-celled by the meeting of the placentæ in the axis, seeds very numerous, small.

I. ASCYRUM.

Small shrubs with brown shreddy bark and smooth 2-edged branches; leaves sessile; flowers mostly solitary, yellow; sepals 4, the outer pair orbicular or cordate, the inner narrow; petals 4, oblique; stamens many, distinct or slightly united at the base; styles 2–4, ovary 1-celled with 2–4 parietal placentæ; capsule 2–4-valved.

1. A. STANS Michx. ST. PETER'S-WORT. An erect, branching shrub, 2–3 ft. high; leaves oval or oblong-oval, sessile, obtuse, entire; pedicels 2-bracted below the middle; outer sepals orbicular-cordate, the inner lanceolate; petals obovate, longer than the sepals; capsule shorter than the sepals. June–September. Common on pine barrens.

2. A. HYPERICOIDES L. ST. ANDREW'S CROSS. Stems branching, low and decumbent, 5–12 in. long; leaves oblong or narrowly obovate, narrowed to the sessile base; pedicels 2-bracted above the middle; outer sepals oval, obtuse, double the length of the pedicel, inner sepals very small; petals oblong, approximate in pairs; styles 2; capsule as long as the sepals. June–September. On dry, sandy soil.

II. HYPERICUM.

Herbs or shrubs; leaves opposite, sessile or short-petioled, punctate or black-dotted; flowers yellow, mostly cymose;

sepals 5, equal or nearly so; petals 5, oblique; stamens numerous, distinct or united in sets; styles 3–5, distinct or united, ovary 1- or sometimes 3–5-celled.

1. H. MACULATUM Walt. SPOTTED ST. JOHN'S-WORT. Perennial from a woody base; stem erect, branched above, 2–3 ft. high; leaves oval, obtuse at the apex, clasping at the base, conspicuously black-dotted; cymes large, many-flowered, pedicels short; sepals lanceolate, acute; petals twice the length of the sepals, black-dotted; stamens numerous, in 3–5 sets; styles 3, twice as long as the ovoid, 3-celled ovary. June–August. Dry pine barrens.

2. H. MUTILUM L. DWARF ST. JOHN'S-WORT. Annual; stem erect, 4-angled, branched above, 9–15 in. high; leaves oblong or ovate, obtuse at the apex, clasping at the base, 5-nerved; cymes many-flowered, bracted, branches slender; sepals lanceolate, about the length of the petals; stamens 6–15, distinct; styles separate; capsule green, ovoid, 1-celled. June–August. Common on low ground.

III. SAROTHRA.

Annual; stem erect, branched above; leaves opposite, linear or subulate; flowers scattered on the branches, small, short-pediceled or sessile; sepals 5, regular; petals 5; stamens 5–10; styles 3, distinct, ovary 1-celled; seeds striate.

S. GENTIANOIDES L. PINE-WEED. Stem with numerous erect, wiry branches, 9–18 in. high; leaves minute, bract-like; flowers sessile, yellow; sepals linear, half the length of the acute, purple capsule. May–August. In old fields on sandy soil.

81. CISTACEÆ. ROCK-ROSE FAMILY.

Low shrubs or herbs; leaves simple, alternate or opposite; flowers solitary or clustered, regular, usually perfect; sepals 5, the 2 outer ones smaller and bract-like, persistent; petals 5, rarely wanting; stamens few or numerous, distinct, hypogynous; style 1, stigma entire or 3-lobed; ovary 1-celled, several-seeded.

HELIANTHEMUM.

Herbs, sometimes woody at the base; stem branching; flowers often of 2 kinds, the one with large and showy petals, the other small and inconspicuous, both perfect; stamens few or numerous; style short or wanting; stigma capitate or 3-lobed.

1. H. [illegible] Michx. [illegible]. Perennial from a woody base, stems villous, [illegible] in. high; leaves short-petioled, lanceolate, or the lower oblong, acute, [illegible], margins revolute; flowers [illegible] of large and [illegible] petals, [illegible]; capsule [illegible]. March–April. Dry, sandy soil.

2. H. Canadense (L.) Michx. Frostweed. Perennial from a woody base; stems [illegible], [illegible] branched, [illegible] in. high; leaves lanceolate or oblong, [illegible], margin revolute; flowers [illegible] of 2 kinds, the larger [illegible], solitary, the smaller [illegible], [illegible]; [illegible] than the [illegible] capsule. April–June. Dry, sandy soil.

[illegible] VIOLACEÆ. VIOLET FAMILY.

Herbs (ours) [illegible], leaves simple, basal or alternate, stipulate; flowers usually solitary, perfect, irregular; sepals 5, persistent; petals 5, irregular, the lower one usually saccate or spurred; stamens 5, hypogynous, connivent; style single; ovary 1-celled, with 3 parietal placentæ; 3-valved, many-seeded.

VIOLA.

Annual or perennial, acaulescent or with a leaf-bearing stem; leaves usually entire or much divided; flowers single, long-peduncled; sepals prolonged at the base; lower petal spurred; filaments of the two upper stamens prolonged [illegible] the anthers; style usually bent and [illegible]; many species producing [illegible] flowers on short peduncles late in the season.

1. V. PALMATA L. EARLY BLUE VIOLET. Acaulescent from a thick and scaly rootstock; leaves long-peduncled, broadly cordate in outline, the earlier nearly entire, the later with the lower part deeply lobed or cleft, the upper part crenate or dentate; petioles and peduncles pubescent, peduncles becoming longer than the petioles; flowers blue; lateral petals and style bearded; apetalous flowers on reflexed peduncles abundant late in the season. February–June. Common in dry woods.

2. V. OBLIQUA Hill. MEADOW VIOLET. Acaulescent from a thick rootstock; leaves on long and slender petioles, not divided, ovate to broadly reniform, apex mostly acute, the sides rolled inward when young, crenate or dentate; flowers blue or sometimes white; lateral petals bearded, often with darker veins; stigma beakless. February–June. Common on low ground.

3. V. PEDATA L. BIRD'S-FOOT VIOLET. Acaulescent from a thick, erect rootstock; smooth or nearly so; leaves orbicular or reniform, deeply parted into numerous linear or narrow lobes which are often toothed at the apex; peduncles longer than the petioles, bracted; flowers mostly blue, the upper petals sometimes darker, whole flower occasionally white; petals not bearded; apetalous flowers none. March–May. On dry hills.

4. V. ODORATA L. ENGLISH SWEET VIOLET. Tufted from stoloniferous rootstocks, smooth or somewhat pubescent; leaves round-cordate, crenate; peduncles bracted, longer than the petioles; flowers blue or sometimes white, very fragrant; petals not bearded; apetalous flowers abundant late in the season. February–May, or all the winter. Common in cultivation.

5. V. PRIMULÆFOLIA L. PRIMROSE-LEAVED VIOLET. Rootstock slender, producing numerous long runners rooting at the joints; leaves ovate, crenate, smooth or hairy, decurrent on the long petiole; peduncles longer than the leaves; flowers white; petals often acute, the lower ones bearded and veined with purple. March–June. On low ground.

6. V. HASTATA Michx. HALBERD-LEAVED VIOLET. Perennial; stem smooth or hairy, simple, ascending or erect, 6–12 in. high; leaves deltoid-ovate, often hastate-lobed, crenate; stipules small, entire; flowers yellow, on axillary peduncles; lateral petals bearded, the lower with purple veins. April–May. Shaded hillsides.

7. V. TRICOLOR L. PANSY. Annual; stem smooth or hairy, angled, diffuse; leaves ovate to spatulate, irregularly crenate-dentate; stipules large, foliaceous, toothed or pinnatifid; flowers of many colors. Common in gardens.

8. V. TENELLA Muhl. FIELD PANSY. Annual; stems slender, glabrous, angled, erect, 5–8 in. high; leaves petioled, mostly orbicular, crenate or dentate; stipules large, toothed and pinnatifid; flowers

small, long-peduncled, lurid purple and yellow. March–May. Common in dry, cultivated ground. Very similar to the cultivated Pansy, but much smaller.

83. PASSIFLORACEÆ. PASSION-FLOWER FAMILY.

Shrubs or herbs, climbing by axillary tendrils; leaves alternate, simple, mostly 3-lobed; flowers axillary, on jointed peduncles, solitary or few together, perfect, regular, often showy; calyx tube 4–5-lobed, persistent; petals usually 5, inserted on the throat of the calyx tube which is fringed with a crown of 1–3 rows of long and slender filaments; stamens 5, their filaments united, and enclosing the stipe of the ovary; styles 1–5, ovary with 3–5 parietal placentæ; seeds numerous, fruit fleshy.

PASSIFLORA.

Characters of the family.

1. P. INCARNATA L. PASSION-FLOWER. Perennial; stem often 10–30 ft. long, somewhat angled or striate, smooth below, pubescent above; leaves broadly cordate, palmately 3–5-lobed, the lobes acute, finely serrate, usually cordate at the base, petiole bearing 2 small glands near its summit; flowers 2–3 in. wide, solitary; peduncles 3-bracted, longer than the petioles; calyx lobes with a small horn-like appendage on the back near the apex, white within; petals and crown purple and white; fruit yellow, about the size and shape of a hen's egg, edible; seeds with a pulpy aril. May–July. Common along fence rows and embankments.

2. P. LUTEA L. YELLOW PASSION-FLOWER. Perennial; stem slender, glabrous, 6–10 ft. long; leaves broadly cordate, 3-lobed at the summit, entire, often mucronate; stipules small; petioles glandless; peduncles longer than the leaves, usually in pairs; flowers greenish-yellow, ½–¾ in. wide; fruit purple, small, ½ in. long. May–July. Woods and thickets.

84. CACTACEÆ. CACTUS FAMILY.

Succulent shrubs; stems globose, flattened or terete, ridged and tubercled, often jointed and usually spiny; leaves none.

or very small and fleshy; flowers showy, solitary, sessile; sepals and petals many and similar, adherent to the 1-celled ovary; stamens numerous, inserted on the base of the petals; style single, stigmas many; fruit a fleshy, many-seeded berry.

OPUNTIA.

Stems in flattened or cylindrical joints; leaves small, fleshy, on the upper parts of the younger joints, with a tuft of hairs and a few strong spines in the axils; sepals and petals not united to form a tube above the top of the ovary; stamens very numerous; style longer than the stamens, 3–8-divided; fruit bristly.

1. O. Opuntia (L.) Coult. Prickly Pear. Prostrate or ascending; stems with oval or obovate, flattened joints; leaves soon deciduous; spines few, solitary; flowers from the edges of the joints, near the summit, yellow, often variegated with red, 2–3 in. wide; fruit obovoid, purple, edible, 1–1½ in. long. June–August. Dry, barren soil.

2. O. Pes-Corvi LeC. Crowfoot Cactus. Prostrate or ascending; joints cylindrical or slightly flattened, 1–3 in. long, separating easily; spines in pairs, unequal; sepals and petals 8–12; stigmas 4; fruit small, fleshy, bristly, 1–4-seeded. May–June. On sandy soil, more common along the coast.

85. THYMELEACEÆ. MEZEREON FAMILY.

Shrubs or trees, with acrid sap; bark tough and fibrous; leaves simple, alternate, exstipulate; flowers regular, perfect, in axillary clusters; calyx tube cylindrical, 4-5-toothed or entire; petals none; stamens 8 in 2 rows, inserted on the calyx, exserted, the alternate ones longer; ovary superior, 1-celled, 1 ovuled, style long, stigma capitate; fruit a drupe.

DIRCA.

Shrubs; bark very tough, with interwoven fibers; leaves deciduous, short-petioled; flowers in small clusters from buds on shoots of the previous season, and protected by hairy

scales; branches often developed later from the same buds; peduncles short, 2–4-flowered; calyx tube entire or slightly 4-toothed; stamens and style long exserted; drupe small, oval, red.

D. PALUSTRIS L. LEATHERWOOD. A branching shrub, 2–5 ft. high; leaves oblong or obovate, obtuse at the apex, rounded at the base, entire, pubescent when young, becoming smooth with age; peduncles short, 3-flowered; flowers light yellow, bud-scales 3–4, oval, downy; drupe $\frac{1}{3}$–$\frac{1}{2}$ in. long. February–March. Banks of streams.

86. LYTHRACEÆ. LOOSESTRIFE FAMILY.

Trees, shrubs or herbs; leaves opposite or alternate; stipules none; flowers solitary or clustered; calyx tube enclosing the ovary and sometimes coherent with it, 4–8-toothed; petals as many as the calyx lobes or none, inserted on the calyx with the few or many stamens; ovary 1–6-celled, style 1, stigma capitate or 2-lobed; fruit capsular or baccate, usually many-seeded.

I. LAGERSTRŒMIA.

Shrubs or small trees; bark smooth and exfoliating in longitudinal plates; branches winged; leaves alternate; flowers in large terminal panicles; calyx tube bell-shaped; stamens numerous, exserted.

L. INDICA L. CRAPE MYRTLE. Small trees, trunk often greatly enlarged at the surface of the ground; leaves oval or oblong, rounded at each end, mucronate at the apex, thick, entire, smooth; flowers pink, purple or white; petals 6, large, crisped, claw slender; style long exserted; fruit a many-seeded capsule. April–June. Introduced from India.

II. PUNICA.

Shrubs or small trees; leaves opposite; calyx tube adherent to the ovary; stamens very numerous, unequal; style long; fruit a several-celled, many-seeded berry.

P. GRANATUM. POMEGRANATE. Erect, branching shrubs; leaves lanceolate or ovate, acute at the apex, rounded at the base, entire; flowers solitary, short-peduncled; calyx and corolla bright red; calyx lobes 5, triangular, persistent; petals 5, oval, erect; fruit globose, crimson, 3–4 in. in diameter, 3-celled below and 5-celled above, edible; seeds many, surrounded by a pulpy aril having a pleasant acid taste. May–June. Introduced from Europe.

87. MELASTOMACEÆ. MEADOW-BEAUTY FAMILY.

Perennial herbs; leaves simple, opposite, 3–9-ribbed, exstipulate; flowers in terminal cymes; calyx tube urn-shaped, constricted at the neck, 4-lobed, persistent; petals 4, inserted in the throat of the calyx tube, oblique; stamens usually twice the number of the petals, anthers often long, curving upward and spurred at the base; ovary superior, 4-celled, placentæ central, style single, bent to one side; fruit a many-seeded, 4-celled capsule.

RHEXIA.

Characters of the family.

1. R. MARIANA L. DEER-GRASS. Stem erect, branched, terete or 6-angled, bristly, 1–2 ft. high; leaves lanceolate or linear-oblong, short-petioled, acute, 3-nerved, bristly on both sides, ciliate-serrate; flowers purple, $1\frac{1}{2}$–2 in. wide; calyx tube bristly or nearly smooth, the neck as long as the globose portion; petals rounded; anthers curved, saccate at the base. June–September. In wet, sandy soil.

2. R. VIRGINICA L. MEADOW-BEAUTY. Stem erect, nearly simple, hairy or bristly, 4-angled, 10–15 in. high; leaves oval or ovate-lanceolate, sessile, 3–5-nerved, both surfaces with scattered hairs, bristly serrate; flowers bright purple, 1–$1\frac{1}{2}$ in. wide; calyx bristly, the neck shorter than the globose portion; petals rounded, usually truncate at the apex; anthers curved, spur small. June–September. In swamps.

3. R. GLABELLA Michx. SMOOTH MEADOW-BEAUTY. Stem erect, mostly simple, smooth, 2–3 ft. high; leaves lanceolate or elliptical, sessile, entire or faintly serrate, thick, smooth, and glaucous; flowers bright purple, $1\frac{1}{2}$–2 in. wide; calyx often glandular-hispid; petals obovate; anthers long and curved. June–August. Low pine barrens.

4. R. LUTEA Walt. YELLOW MEADOW-BEAUTY. Stem erect, widely branched, 4-angled, bristly, 10–15 in. high; lower leaves spatulate or obovate, the upper lanceolate and acute, all nearly smooth, margin bristly serrulate; flowers numerous, about 1 in. wide; calyx tube short, smooth, much constricted, the lobes cuspidate; petals yellow; stamens straight, erect. June–August. Damp woods.

88. ONAGRACEÆ. EVENING PRIMROSE FAMILY.

Herbs, or rarely shrubs; leaves simple, opposite or alternate, exstipulate but sometimes with basal glands; flowers solitary, spiked or racemed; calyx adherent to the ovary, and often prolonged into a tube beyond it, usually 4-lobed; petals distinct, usually 4, sometimes none; stamens 4 or 8, inserted with the petals at the top of the calyx tube; ovary 1–6-celled, style 1, simple or 4-parted; fruit a capsule or berry, dehiscent or indehiscent, 1–many-seeded.

I. LUDWIGIA.

Perennial herbs, often stoloniferous; leaves simple, opposite or alternate, entire; flowers axillary or terminal; calyx tube not prolonged beyond the ovary, cylindrical or obconic, usually crowned with 4 persistent lobes; petals 4, roundish or obcordate, often wanting; stamens 4, short; style capitate or 4-lobed; capsule 4–5-celled, winged or angled, many-seeded.

1. L. ALATA Ell. WINGED LUDWIGIA. Stem erect, smooth, simple or branched, winged, often stoloniferous, 2–3 ft. high; leaves alternate, oblanceolate or almost linear, nearly or quite sessile, obscurely dentate; flowers axillary or in terminal spikes, small, sessile; calyx glabrous; petals none; capsule cubical or obpyramidal, angles winged; seeds ovoid, faintly pitted. June–September. On marshy ground.

2. L. HIRTELLA Raf. HAIRY LUDWIGIA. Stem erect, slender, simple or sparingly branched, hairy, 2–3 ft. high; leaves alternate, lanceolate or oblong, obtuse at the apex, sessile and rounded at the base, hirsute; flowers axillary, on 2-bracted pedicels; calyx lobes erect or spreading, lanceolate, acute, about half as long as the yellow, obovate petals, and longer than the cubical, hairy capsule. June–September. In flat pine barrens.

3. L. ALTERNIFOLIA L. RATTLE-BOX. Stem erect, much branched, smooth or pubescent, 2–3 ft. high; leaves alternate, short-petioled, lanceolate or elliptical, acute; flowers axillary, or the upper ones somewhat racemed, on short 2-bracted peduncles; calyx lobes ovate, acute, spreading, deciduous, about as long as the obovate, yellow, caducous petals; capsule smooth, cubical, angles slightly winged. June–September. In swamps.

II. JUSSIÆA.

Perennial herbs; stems erect or creeping, smooth; leaves alternate, petioled or sessile; flowers solitary, axillary, white or yellow; calyx tube not prolonged beyond the ovary, the limb 4–6-lobed, persistent; petals 4–6; stamens 8–12, in 2 rows, inserted with the petals; stigma 4–6-lobed; capsule elongated, angled, 4–6-celled, many-seeded.

J. DECURRENS (Walt.) DC. UPRIGHT JUSSIÆA. Stem erect, smooth, angled, branched above, 1–3 ft. high; leaves alternate, lanceolate, entire, smooth, acute at the apex, sessile and decurrent on the stem; flowers nearly sessile; calyx lobes 4, lanceolate, acuminate; petals 4, yellow, obovate, a little longer than the calyx lobes; stamens 8; capsule oblong-clavate, 4-angled, many-seeded. June–September. On wet soil.

III. ONAGRA.

Annual or biennial herbs; stems erect; leaves alternate, toothed, sessile or short-petioled; flowers in terminal, leafy spikes, yellow, nocturnal; calyx tube prolonged beyond the ovary, the lobes narrow, becoming reflexed and deciduous; petals 4; stamens 8, equal in length; style elongated, stigma 4-parted; capsule 4-celled, 4-angled, many-seeded.

O. BIENNIS (L.) Scop. EVENING PRIMROSE. Biennial, or sometimes annual; stem stout, erect, branched above, hirsute or nearly smooth, 2–6 ft. high; leaves oblong-lanceolate, acute at the apex, sessile or narrowed into a petiole below, wavy-denticulate, smooth or pubescent; flowers sessile, bright yellow or nearly white, opening in the evening, $1\frac{1}{2}$–2 in. broad; calyx tube slender, 2–3 in. long; petals obovate, retuse; capsule oblong, narrowed at both ends, rough, hairy, obtusely 4-angled, $\frac{3}{4}$–1 in. long. June–October. Common on dry soil.

IV. KNEIFFIA.

Annual, perennial, or sometimes shrubby; leaves alternate, usually narrow; flowers in terminal spikes or racemes, yellow, diurnal; calyx tube prolonged beyond the ovary, the lobes often united at the apex, finally becoming reflexed; petals 4; stamens 8, the alternate ones longer; style slender, stigma 4-parted; capsule sessile or peduncled, clavate, 4-angled, seeds many.

1. K. LINEARIS (Michx.) Spach. NARROW-LEAVED PRIMROSE. Biennial or perennial; stem erect or ascending, slender, simple or branched, smooth or pubescent, 12–18 in. high; lower leaves obovate, the upper linear or linear-spatulate, entire or slightly toothed; racemes terminal, short, leafy, many-flowered; flowers yellow, 1–1½ in. broad; calyx pubescent, the tube ⅓ in. long; petals obcordate; capsule narrowly obovate, prominently 4-winged with 4 intermediate ribs, shorter than the pedicel. April–June. On dry, sandy soil.

2. K. FRUTICOSA (L.) Raim. SUNDROPS. Perennial; stem erect, simple or branched, more or less pubescent; leaves lanceolate, sessile or short-petioled, wavy-denticulate on the margins; racemes terminal, finally much elongated; flowers yellow, diurnal, 1½–2 in. broad; calyx tube longer than the ovary; petals obcordate; capsule oblong-clavate, sessile or nearly so, prominently 4-winged with intermediate ribs, longer than the pedicel. June–September. In old fields.

V. GAURA.

Annual, biennial or perennial herbs, sometimes woody at the base; leaves alternate, sessile; flowers in terminal spikes or racemes; calyx tube slender, prolonged beyond the ovary, 4-lobed, the lobes reflexed; petals 4, long-clawed, unequal; stamens 6–8, usually turned to one side; style declined, stigmas 4-lobed, ovary 3–4-celled; fruit a 3–4-angled capsule, mostly 1-celled, 3–4-seeded.

1. G. BIENNIS L. BIENNIAL GAURA. Biennial; stems erect, widely branched, soft-pubescent, 3–8 ft. high; leaves oblong-lanceolate or elliptical, acuminate, wavy-denticulate, pubescent or becoming smooth above; flowers sessile in long-peduncled spikes; petals white, fading to pink; fruit sessile, narrowly ovoid, obtusely 4-angled, pubescent. June–September. On dry soil, more common northward.

2. G. Michauxii Spach. Michaux's Gaura. Stem erect, slender, paniculately branched above, pubescent when young, becoming smooth or glabrous, 2–4 ft. high; leaves very numerous, broadly linear, toothed, wavy-margined; racemes long-peduncled, few-flowered: flowers on slender pedicels, white, fading to pink; fruit ovoid, obtuse, sharply 4-angled; capsule about as long as the pedicel. June-August. Dry pine barrens, more common southward.

VI. FUCHSIA.

Shrubs; leaves opposite or sometimes in 3's; flowers axillary, long-peduncled; calyx tube prolonged beyond the ovary, limb 4-parted, colored and corolla-like, deciduous; petals 4; stamens 8, exserted, unequal; style long and exserted; disk glandular, 8-furrowed; fruit a many-seeded berry.

F. coccinea Curt. Fuchsia. Stem erect, widely branched; leaves smooth, oval to cordate, denticulate, thick, smooth; flowers drooping; calyx red or white; corolla purple, red or white; stamens and style long, exserted, filaments usually colored; fruit oval, somewhat 4-sided. A common house-plant, introduced from Brazil.

89. ARALIACEÆ. GINSENG FAMILY.

Herbs, shrubs or trees; leaves compound; flowers in umbels which are often paniculate, polygamous or sometimes perfect; calyx tube adherent to the ovary, its limb 5-toothed or truncate; petals usually 5, small, flat, and spreading, inserted on the summit of the calyx tube; stamens as many as the petals and alternate with them; styles 2–5; fruit a 1–several-celled drupe or berry.

I. ARALIA.

Herbs, shrubs or trees; leaves alternate, pinnately decompound, base of the petiole sheathing; umbels in cymes or panicles; flowers small, white or greenish, on jointed pedicels; calyx 5-toothed or truncate; petals, stamens and styles 5; fruit usually a 5-seeded berry.

1. A. spinosa L. Hercules's Club. A small tree, stem, branches and petioles with very numerous, large prickles; leaves

long-petioled, bipinnately compound, leaflets stalked, ovate, acuminate at the apex, obtuse and inequilateral at the base, serrate, thick, smooth and shining above, glaucous and slightly pubescent beneath, often with smaller leaflets intermixed; umbels in very large, terminal, hoary or pubescent panicles; flowers small, white; styles distinct; fruit ovoid, 5-lobed, black, about as long as the pedicel. June–August. In swamps, often cultivated.

2. A. RACEMOSA L. SPIKENARD. Perennial herb; root thick, aromatic; stem erect, smooth, widely branched, 3–5 ft. high; leaves ternately decompound, leaflets cordate, acuminate at the apex, sharply and doubly serrate; umbels in large panicles; flowers small, greenish; styles united below; fruit dark brown or purple, globose. June–July. In rich woods.

3. A. NUDICAULIS L. SARSAPARILLA. Perennial herb; roots very long, somewhat fleshy, aromatic; stem very short or none; leaf solitary from a sheathing base, petioled, 6–12 in. long; ternately divided, the divisions 3–5-pinnate; leaflets oval or ovate, acuminate, finely and sharply serrate, smooth above, often pubescent below; scape nearly as long as the petiole, usually bearing 3 short-peduncled umbels; flowers greenish; styles distinct; fruit globose, black. May–June. In rich woods.

II. PANAX.

Perennial herbs; root fleshy, aromatic; stem naked, with a whorl of palmately compound leaves and a single umbel of greenish flowers at its summit; calyx minutely 5-toothed; petals and stamens 5; styles 2–3; fruit a drupe-like berry with 2–3 seeds.

P. QUINQUEFOLIUM L. GINSENG. Root fusiform, often forked, 3–5 in. long; stem erect, glabrous; leaflets 5–7, stalked, the upper longer, oval or obovate, acuminate at the apex, sharply and unevenly serrate; umbel 5–15-flowered, pedicels short, peduncles 1–2 in. long; flowers small, greenish-yellow; styles 2; berry compressed-globose, bright red, 2–3-seeded. June–August. In rich, shady woods.

90. UMBELLIFERÆ. PARSLEY FAMILY.

Herbs; stems usually hollow and grooved; leaves alternate, simple, compound or decompound, base of the petiole usually sheathing; flowers small, in simple, compound or decompound umbels, or sometimes in close heads; base of the umbel usually

subtended by an involucre, and the divisions of the compound umbel by involucels; calyx tube adnate to the ovary, truncate or minutely 5-toothed; petals and stamens 5, inserted in the disk at the top of the calyx tube; ovary 2-celled, styles 2, distinct; fruit of 2 carpels which separate from each other at maturity, each carpel with 5 longitudinal ribs, and often 4 additional ribs between them; oil tubes are usually present under or between the ribs. [The flowers are all so much alike, and the foliage varies so widely in species of the same genus, that the characters for classification depend almost wholly upon minute structural peculiarities of the fruit, making the family an exceedingly difficult one for study. There are about 27 genera and 51 species in our region, but most of them flower late in the season.]

I. DAUCUS.

Annual or biennial herbs; leaves pinnately decompound, the divisions finely dissected and linear; umbels compound, the outer rays longer; flowers white or pink, involucre of pinnately dissected leaflets, involucels bract-like, entire or toothed; calyx teeth minute or wanting; petals obovate; carpels obovate, ribs 9, prickly or bristly, oil tubes 6.

D. PUSILLUS Michx. WILD CARROT. Stem erect, simple or with a few branches above, rough-hispid, 1–2 ft. high; leaves twice pinnate, divisions linear; umbels long-peduncled, markedly concave on the top; bristles of the fruit barbed or hooked, adhering readily to hair and clothing. June–July. On dry, sterile soil, often a troublesome weed.

II. PASTINACA.

Biennial or sometimes annual, from a straight, fleshy root; stem erect, widely branched above; leaves pinnate; umbels compound, involucre and involucels none; flowers yellow; calyx teeth none; fruit flattened dorsally; lateral ribs winged, the others inconspicuous.

P. SATIVA L. PARSNIP. Root long-conical, fleshy; stem erect, branched, pubescent above, glabrous below, 2–5 ft. high; lower leaves long-petioled, pinnate, the divisions sessile, acute or oval, irregularly incised or lobed, sharply and unevenly serrate, upper leaves similar but much smaller; umbels numerous, compound, 7–15-rayed, rays slender, umbellets 5–10-rayed; fruit smooth, broadly oval, nearly as long as the pedicels, lateral ribs and oil tubes prominent, intermediate ribs reduced to slight ridges. June–August. Escaped from cultivation and sometimes a troublesome weed; root reputed to be poisonous in its wild state.

III. THASPIUM.

Perennial herbs; stem erect; leaves 1–2-ternately compound; umbels compound, involucre and involucels usually wanting; flowers yellow or purple; calyx teeth small, acute; fruit ovoid or oblong, somewhat laterally compressed; carpels smooth, strongly ribbed, oil tubes between the ribs.

T. BARBINODE (Michx.) Nutt. HAIRY MEADOW PARSNIP. Stem erect, branching above, pubescent at the nodes, 2–7 ft. high; leaves petioled, 1–2-ternate, slightly pubescent; leaflets mostly thin, ovate, toothed, incised or lobed toward the apex, entire toward the base; umbels long-peduncled, few-rayed; fruit oblong, lateral and central ribs strongly winged. May–June. Along streams.

IV. ERYNGIUM.

Annual, biennial or perennial herbs; stems erect or creeping; leaves simple, mostly linear and spiny-toothed; flowers white or blue, in dense, bracted heads or spikes, flowers bracteolate; calyx teeth rigid, persistent; petals erect, pointed; styles slender; fruit turbinate, scaly or granular, ribs obsolete, oil tubes usually 5, minute.

E. AQUATICUM L. BUTTON SNAKEROOT. Perennial; stem erect, branched above, striate, glaucous, 2–3 ft. high; leaves linear, often 2 ft. or more in length, rigid, glaucous, parallel-veined, fringed with white bristles; bracts shorter than the heads, entire, bracteoles similar but smaller; flowers white; fruit scaly. May–July. On damp soil.

V. SANICULA.

Perennial or biennial herbs; stems erect, glabrous; leaves long-petioled, palmately divided; umbels compound, few-rayed, involucre leaf-like, umbellets few-flowered, involucels small; flowers yellow or purple; fruit flattened laterally, carpels not ribbed but armed with hooked bristles.

S. MARILANDICA L. BLACK SNAKEROOT. Perennial; stem stout, nearly simple, 2–3 ft. high; leaves palmately 5–7-parted, the divisions obovate or oblanceolate, toothed; lower leaves long-petioled, the upper sessile; umbels of 2–4 long rays, leaves of the involucre 3-parted; umbellets with numerous staminate flowers, pistillate flowers few; petals greenish-white; styles elongated and conspicuous, recurved; fruit ovoid, with 5 large oil tubes. May–June. In dry woods.

91. CORNACEÆ. DOGWOOD FAMILY.

Trees or shrubs; leaves simple, alternate, opposite or verticillate, usually entire, exstipulate; flowers perfect, polygamous or diœcious, cymose or capitate; calyx tube coherent with the ovary, 4–5-toothed or truncate; petals 4–5 or wanting; stamens 4–10, inserted with the petals in the disk at the top of the ovary; ovary 1–2-celled, style long or short; fruit a berry-like, 1–2-celled, 1–2-seeded drupe.

I. CORNUS.

Shrubs or small trees; leaves usually opposite or verticillate; flowers perfect, in cymes or heads, the heads subtended by a large involucre; calyx tube minutely 4-toothed; petals 4; stamens 4; stigma capitate or truncate; fruit a 2-celled, 2-seeded drupe.

1. C. FLORIDA L. FLOWERING DOGWOOD. Small trees; bark rough, black; leaves opposite, petioled, ovate to ovate-lanceolate, entire, green and shining above, paler and often pubescent beneath; flowers small, greenish, in heads which are subtended by 4 large, white or pink, obcordate bracts, thickened and greenish at the sinus; fruit ovoid, bright red. April–May. In rich woods.

2. C. Amonum Mill. Kinnikinnik. A shrub, 6–10 ft. high; twigs purple, pubescent when young; leaves opposite, petioled, ovate or oblong, acuminate, smooth above, silky-pubescent below; flowers white, in rather close cymes; drupe blue, stone somewhat oblique. May–June. In low woods.

3. C. asperifolia Michx. Rough-leaved Dogwood. A shrub 8–12 ft. high; twigs slender, reddish-brown, often warty, densely pubescent when young; leaves opposite, short-petioled, lance-ovate or oblong, acute or acuminate, rough-pubescent above, woolly pubescent below; cymes flat, spreading, the peduncle and branches rough-pubescent; flowers white; drupe white or pale blue, stone depressed-globose. May–June. In dry woods.

4. C. alternifolia L. Alternate-leaved Dogwood. A shrub or small tree; twigs greenish, striped; leaves alternate, often clustered at the ends of the twigs, long-petioled, oval, acute at the apex and often at the base, minutely toothed, pale and pubescent beneath; cymes loose and open; flowers white; drupe deep blue, seeds globose. May–June. Banks of streams.

II. NYSSA.

Trees or shrubs; leaves alternate, petioled, entire or few-toothed; flowers polygamous or diœcious, the staminate in many-flowered heads or cymes, the pistillate in small clusters or solitary; calyx tube 5-toothed or truncate; petals minute or wanting; stamens 5–10; ovary 1-celled, 1-ovuled, style long and recurved; fruit a 1-seeded drupe.

1. N. sylvatica Marsh. Black Gum. A tree with widely spreading branches and dark, rough bark, wood light-colored, very tough, base of trunk often enlarged; leaves often clustered at the ends of the twigs, oval or obovate, acuminate or obtuse at the apex, entire, smooth and shining above, pubescent beneath, becoming bright red in autumn; staminate flowers in capitate clusters; pistillate 3–10 in a long-peduncled cluster; drupe ovoid, dark blue or nearly black, ½ in. long, stone slightly ridged. April–May. In rich, wet soil.

2. N. aquatica L. Tupelo. A large tree, similar to the preceding; leaves long-petioled, oval or ovate, acute at each end, entire or coarsely toothed, the lower sometimes cordate, smooth above, tomentose beneath, 4–8 in. long; staminate flowers in capitate clusters; pistillate flowers on long peduncles, solitary; drupe ovoid, dark blue, stone sharply ridged. April. In swamps.

92. CLETHRACEÆ. WHITE-ALDER FAMILY.

Trees or shrubs; leaves alternate, petioled, serrate, deciduous, exstipulate, pubescence stellate; flowers in solitary or clustered terminal racemes, small, white; calyx 5-parted, persistent; petals 5, slightly united below, deciduous; stamens 10, anthers sagittate; ovary free, style slender, 3-cleft, stamens and style exserted; fruit a globose, dehiscent capsule, 3-celled, 3-valved, many-seeded.

CLETHRA.

Characters of the family.

C. ALNIFOLIA L. WHITE ALDER. Shrubs, 3–8 ft. high; twigs and branches tomentose; leaves short-petioled, obovate, acute at the apex, cuneate at the base, serrate, smooth on both sides; racemes simple or panicled, flowers on short pedicels subtended by short, deciduous bracts; flowers $\frac{1}{3}$ in. wide, very fragrant; filaments smooth; style hairy, longer than the stamens; capsule about the length of the calyx. June–July. In damp woods, usually on sandy soil.

93. MONOTROPACEÆ. INDIAN PIPE FAMILY.

Low herbs; saprophytic on decaying roots or vegetable matter; stems fleshy, leafless, but with numerous leaf-like bracts; flowers solitary or clustered, perfect, regular; sepals 2–6, erect, slightly united at the base; petals 2–6, distinct or united; both calyx and corolla deciduous; stamens 6–12, hypogynous, distinct or united; ovary free, style long or short, stigma capitate, or peltate and rayed; fruit a 1–6-celled, many-seeded capsule, seeds minute, reticulated.

I. MONOTROPA.

Stems fleshy, single or clustered, simple; bracts numerous; flowers solitary, nodding, the capsule becoming erect in fruit; sepals 2–4, deciduous; petals 5–6, somewhat persistent; sta-

mens 10–12, anthers peltate; ovary 5-celled, style short, stigma peltate; capsule 5-celled, 5-valved.

M. UNIFLORA L. INDIAN PIPE. Stem smooth, succulent, 4–6 in. high; bracts ovate or lanceolate; flower tubular, $\frac{3}{4}$–1 in. long, inodorous; stamens a little shorter than the petals; capsule angled, $\frac{1}{2}$–$\frac{3}{4}$ in. long; whole plant waxy white, turning black in drying. June–August. In moist, shady woods.

II. HYPOPITYS.

Low, saprophytic herbs; stems erect, simple, pubescent above; bracts numerous; flowers in a one-sided, terminal raceme; terminal flowers usually with 5 petals and 10 stamens; the others with 4 petals and 8 stamens; sepals as many as the petals; petals saccate at the base; ovary free, style longer than the stamens, stigma ciliate; capsule 3–5-celled, many-seeded.

H. HYPOPITYS (L.) Small. PINE-SAP. Stems single or clustered, white or reddish, 4–8 in. high; bracts ovate-lanceolate; flowers succulent, fragrant, $\frac{1}{2}$–$\frac{3}{4}$ in. long; capsule oval, $\frac{1}{4}$ in. long. June–August. In dry, shady woods.

94. ERICACEÆ. HEATH FAMILY.

Trees, shrubs or perennial herbs; leaves alternate or opposite, simple, exstipulate, often evergreen; flowers axillary or terminal, solitary or variously clustered, perfect; calyx 4–5-parted or cleft, usually persistent; corolla 4–5-lobed or parted; stamens 5–10, hypogynous, distinct, anthers 2-celled, often awned; ovary free, 2–5-celled, style long or short, stigma entire or 3-lobed; fruit a 2–5-celled capsule or berry, seeds few or numerous. [Plants of this family are rarely found on lime soils.]

I. AZALEA.

Shrubs, often much branched; leaves alternate, thin, deciduous; flowers very showy in terminal umbels from scaly

buds which become well developed the previous season; calyx very small, 5-parted; corolla bell-shaped, the tube long and slender, the limb spreading and somewhat one-sided; stamens usually 5, sometimes 10, declined, anthers awnless; style long and slender, declined, stigma capitate; capsule oblong or linear, 5-celled, many-seeded, seeds very small, scale-like.

1. A. NUDIFLORA L. WILD HONEYSUCKLE. A branching shrub, 4–6 ft. high; twigs smooth or with a few coarse hairs; leaves obovate or oblong, ciliate-serrate, pubescent, becoming smooth above; petioles short; flowers appearing with or before the leaves, pink or white, sometimes yellowish, fragrant, 1–2 in. wide, tube pubescent but not glandular; capsule erect, linear-oblong, $\frac{2}{3}$–$\frac{3}{4}$ in. long. April–May. Swamps and banks of streams; flowers extremely variable in size and color.

2. A. VISCOSA L. SWAMP HONEYSUCKLE. A shrub, 4–6 ft. high; branches hairy; leaves obovate, coriaceous, mucronate at the apex, mostly smooth above, pubescent on the veins beneath; petioles very short; flowers appearing later than the leaves, white, fragrant, $1\frac{1}{2}$–2 in. long, tube long, glandular-viscid; capsule erect, $\frac{1}{2}$–$\frac{2}{3}$ in. long, bristly. June–July. In swamps.

II. KALMIA.

Erect and branching shrubs; leaves alternate, opposite or in 3's, entire, coriaceous, evergreen; flowers showy, in corymbs or 1–3 in the axils; calyx 5-parted; corolla flat-campanulate or rotate, 5-lobed; stamens 10, the anthers placed in pouches in the corolla, filaments straightening elastically at maturity and so bringing the anthers in contact with the capitate stigma; style long and slender; capsule globose, 5-celled, many-seeded.

1. K. ANGUSTIFOLIA L. SHEEP LAUREL. A shrub 1–3 ft. high, with smooth, nearly erect branches; leaves petioled, opposite or in 3's, oblong, obtuse at both ends, dark green above, paler beneath; corymbs lateral, glandular; flowers purple or crimson, $\frac{1}{3}$–$\frac{1}{2}$ in. broad; pedicels slender, recurved in fruit; calyx pubescent, persistent; style persistent; capsule depressed-globose. April–June. On hillsides; more abundant northward.

2. K. LATIFOLIA L. CALICO BUSH. A shrub 4–10 ft. high; branches stout, smooth; leaves mostly alternate, petioled, elliptical or oval, acute at each end, smooth and green on both sides; corymbs terminal, compound; flowers white to rose color, showy, 1 in. broad;

calyx and corolla glandular; pedicels long, slender, viscid-glandular, erect in fruit; calyx and style persistent. May–June. Shady banks on rocky or sandy soil.

III. LEUCOTHOË.

Shrubs; leaves alternate, entire or serrate, deciduous or persistent; flowers white or pink, in terminal or axillary racemes; pedicels jointed; calyx deeply 5-parted, persistent; corolla cylindrical or urn-shaped, 5-toothed; stamens 10, included, anthers curved or mucronate; disk 10-lobed; ovary 5-celled, style slender, stigma capitate; fruit a 5-celled, 5-valved, many-seeded capsule.

1. L. axillaris (Lam.) Don. Downy Leucothoë. A shrub 2–4 ft. high; branches curved, puberulent when young; leaves oval to elliptical, spinose-serrate, at least near the apex, coriaceous, evergreen, short-petioled, dark green and shining above, paler and slightly pubescent beneath; racemes axillary, sessile, about half the length of the leaves, densely many-flowered; corolla cylindrical; anthers horned at the summit; stigma 5-parted. February–March. Banks of streams.

2. L. racemosa (L.) Gray. Swamp Leucothoë. A shrub 4–10 ft. high; branches straight, smooth or puberulent; leaves ovate or oblong, short-petioled, thin, deciduous, nearly or quite smooth above, pubescent beneath; racemes mostly terminal, longer than the leaves, and appearing with or before them; pedicels jointed; calyx with 2 persistent bracts at the base; anthers 2-awned; style slender, stigma capitate; capsule subglobose. April–June. Margins of swamps and streams.

IV. PIERIS.

Shrubs or small trees; leaves alternate, often persistent and green through the winter; flowers in terminal or axillary racemes or clusters, nodding on bracted pedicels; calyx deeply 5-parted; corolla ovoid, urn-shaped or bell-shaped, 5-lobed with recurved teeth; stamens 10, included, anthers awned or awnless; disk 10-lobed; ovary 5-celled, style thick, stigma truncate; fruit a 5-celled, 5-angled, globose, many-seeded capsule.

P. nitida (Bartr.) B. & H. Fetter-bush. A shrub 2–6 ft. high; branches 3-angled, smooth, yellowish-green; leaves evergreen, oval or oblong, very thick and coriaceous, entire, the margins bor-

dered by a prominent nerve and revolute, short-petioled; flowers in numerous axillary, umbel-like clusters, fragrant; calyx lobe spreading, purple; corolla ovoid with a narrow throat, white or bright pink, $\frac{1}{3}$ in. long; anthers awned; capsule ribbed at the sutures. March–May. Common in low, pine barrens.

V. OXYDENDRUM.

A small tree; leaves alternate, petioled, deciduous; flowers white, in long and slender, one-sided, panicled racemes; pedicels 2-bracted; calyx 5-parted, persistent; corolla ovoid, 5-toothed; stamens 10, about equaling the corolla; ovary 5-celled, style thick; fruit a conical, 5-celled, 5-angled, many-seeded capsule.

O. ARBOREUM (L.) DC. SOUR-WOOD. A small tree with smooth, dark-colored bark; leaves oval to oblong, acuminate, serrulate, smooth on both sides, prominently reticulate-veined, sour to the taste; petioles slender; panicles terminal, pubescent; flowers white, $\frac{1}{4}$ in. long, pedicels curved in fruit; style persistent. April–June. In rich, moist woods.

VI. EPIGÆA.

Prostrate or trailing shrubs; stems rusty-pubescent, 6–12 in. long; leaves alternate, coriaceous, evergreen; flowers in dense, bracted, terminal racemes or clusters; calyx 5-parted, persistent; corolla salver-shaped, 5-lobed; stamens 10, about the length of the corolla tube; ovary 5-lobed, style columnar, stigma 5-lobed; fruit a globose, hairy, 5-celled, many-seeded capsule.

E. REPENS L. GROUND LAUREL. Stems creeping, the young twigs ascending; leaves oval or somewhat cordate, entire, reticulate-veined, smooth above, hirsute beneath; petioles short, hirsute; racemes shorter than the leaves; flowers bright pink, $\frac{1}{2}$ in. broad, very fragrant. February–March. In dry woods, often covering considerable areas.

95. VACCINIACEÆ. HUCKLEBERRY FAMILY.

Shrubs or small trees; leaves alternate, simple, exstipulate; flowers clustered or solitary, perfect; pedicels bracted;

calyx tube adherent to the ovary, 4–5-lobed; corolla globose, tubular or campanulate, 4–5-lobed; stamens twice as many as the lobes of the corolla, filaments usually short, flattened; ovary 2–10-celled, style slender, stigma simple or minutely lobed; fruit a globose berry, 2–10-celled, cells 1–several-seeded. [Rare on lime soils.]

I. GAYLUSSACIA.

Low branching shrubs, mostly resinous-dotted; leaves serrate or entire; flowers small, white or pink, in lateral, bracted racemes, nodding; pedicels usually 2-bracteolate; calyx tube short, obconic, the lobes persistent; corolla ovoid to bell-shaped, 5-lobed, the lobes erect or recurved; stamens equal, usually included, anthers awnless; fruit a 10-seeded berry.

1. G. FRONDOSA (L.) T. & G. TANGLEBERRY. An erect shrub 1–3 ft. high; branches spreading, slender, gray, slightly pubescent; leaves entire, oblong or obovate, obtuse, thin, smooth and green above, paler, pubescent, and with resinous dots beneath; petioles short; racemes few-flowered; corolla small, greenish-pink, short-bell-shaped; bracts small, oblong, shorter than the pedicels; berry depressed-globose, dark blue, glaucous, sweet, about $\frac{1}{3}$ in. in diameter. April–May. On low ground.

2. G. DUMOSA (Andr.) T. & G. DWARF HUCKLEBERRY. A branching shrub, 1–2 ft. high; branches pubescent above, usually leafless below; leaves thick and firm, oblong-obovate, obtuse, sessile or nearly so, serrulate, soon smooth and shining above, pubescent or hirsute below; racemes short, few-flowered; bracts ovate, leaf-like, usually longer than the hirsute pedicels; corolla white, bell-shaped, angled; berry black, $\frac{1}{3}$–$\frac{1}{2}$ in. in diameter, insipid. April–May. Low, sandy pine barrens and swamps.

II. VACCINIUM.

Shrubs or small trees; leaves entire or serrulate, often coriaceous and evergreen; flowers terminal or lateral, clustered or solitary, nodding; pedicels 2-bracteolate; calyx tube globose or hemispherical, 4–5-lobed, persistent; corolla urn-shaped, cylindrical or campanulate, 4–5-lobed; stamens twice as many as the lobes of the corolla, anthers awned or awn-

less; ovary 4–5-celled, each cell partially divided by a partition which makes the ovary appear 8–10-celled, style slender, stigma simple; fruit a many-seeded berry.

1. V. corymbosum L. High-bush Blueberry. An erect shrub, 6–12 ft. high; branches rigid, young twigs minutely warty; leaves deciduous, oval to ovate-lanceolate, acute, margins bristly, serrulate, smooth or pubescent, short-petioled; racemes numerous, appearing with or before the leaves; bracts oval or oblong, deciduous; flowers white or pink; corolla almost as long as the pedicel, cylindrical; berry globose, blue or black, flavor slightly acid, pleasant. February–April. Common in woods and thickets, whole plant extremely variable.

2. V. stamineum L. Deerberry. An erect shrub, 3–10 ft. high; branches widely spreading, twigs smooth or puberulent; leaves deciduous, oval or oblong, acute or acuminate at the apex, obtuse or slightly cordate at the base, firm, smooth, and green above, pale and slightly pubescent beneath, petioled; racemes with leaf-like bracts; flowers numerous, drooping, on jointed, slender pedicels; corolla bell-shaped, purplish-green; 2-awned anthers and style exserted; berry globose or pear-shaped, inedible. April–June. Dry woods.

3. V. arboreum Marsh. Farkleberry. Tree-like, sometimes 30 ft. high; bark gray; twigs slender, smooth or pubescent; leaves deciduous, ovate or oval, mucronate, entire or glandular-dentate, coriaceous, green above, often slightly pubescent beneath; racemes with leaf-like bracts; pedicels slender, drooping; corolla campanulate, white; anthers included; style exserted; berry globose, black, mealy, ripening in winter. May–June. Common in dry, open woods.

96. PRIMULACEÆ. PRIMROSE FAMILY.

Annual or perennial herbs; leaves scattered, or clustered and radical; inflorescence various, flowers regular, perfect; calyx free or adherent to the base of the ovary, usually 4–5-lobed and persistent; corolla 4–5-lobed; stamens as many as the lobes of the corolla and opposite them, inserted on its tube or hypogynous, filaments distinct or slightly united at the base; ovary 1-celled, with a free central placenta, style single, stigma entire, capitate; fruit a 1-celled, many-seeded capsule.

I. STEIRONEMA.

Perennial herbs; leaves opposite or whorled, simple, entire; flowers yellow, axillary or racemose, on slender peduncles; calyx tube 5-parted, persistent; corolla 5-parted, rotate, tube very short or none, the lobes denticulate at the apex, and in the bud each one enclosing a stamen; stamens 5, distinct or slightly united at the base, sterile rudiments often alternating with them; ovary globose, style slender; fruit a globose, 5-valved, few or many-seeded capsule.

1. S. CILIATUM (L.) Raf. FRINGED LOOSESTRIFE. Stems erect, slender, simple or branched, 1–3 ft. high; leaves opposite, ovate to ovate-lanceolate, acute at the apex, rounded at the base, margins and petioles hairy-fringed; flowers solitary on axillary peduncles, $\frac{3}{4}$–1 in. broad; petals broadly ovate or roundish, denticulate; calyx shorter than the capsule. June–August. Woods and thickets.

2. S. LANCEOLATUM (Walt.) Gr. LANCE-LEAVED LOOSESTRIFE. Stem erect, slender, smooth, simple or branched, 1–3 ft. high; leaves opposite or the upper ones whorled, the lower leaves petioled, broadly ovate or orbicular, the upper linear-lanceolate or linear, sessile, margins smooth or ciliate; flowers on slender axillary branches, $\frac{1}{2}$–$\frac{3}{4}$ in. broad; petals cuspidate; capsule nearly as long as the calyx lobes. June–August. On damp soil.

II. ANAGALLIS.

Annual or perennial herbs; stems erect or diffuse; leaves opposite or whorled; flowers axillary, peduncled; calyx tube 5-parted, persistent; corolla rotate, 5-parted, longer than the calyx; stamens 5, inserted on the base of the corolla, filaments bearded; ovary globose, style slender, stigma capitate; fruit a many-seeded capsule with circumscissile dehiscence.

A. ARVENSIS L. POOR MAN'S WEATHER-GLASS. Annual; stem spreading, widely branched, 4-angled, smooth, 4–12 in. long; leaves opposite, sessile, ovate, black-dotted beneath; flowers on peduncles longer than the leaves, nodding in fruit; corolla glandular-ciliate, longer than the acute calyx lobes, bright red, opening in sunshine; capsule globose, tipped by the persistent style. May–July. Introduced, and common in fields and gardens.

III. DODECATHEON.

Perennial, acaulescent herbs; leaves all radical, in a rosulate tuft; flowers in an involucrate umbel at the summit of a naked scape; calyx 5-cleft, the lobes reflexed; corolla 5-cleft, tube very short, lobes reflexed; stamens 5, filaments short and united at the base, anthers long and erect; ovary free from the calyx, style long and slender, exserted, stigma capitate; fruit an oblong, many-seeded capsule.

D. Meadia L. Shooting Star. Rootstock stout; leaves spatulate or oblong, tapering into a petiole, smooth, entire or crenate; scape smooth, 10–20 in. high; umbel many-flowered, flowers showy, nodding on long and slender pedicels which become erect in fruit; corolla purple or white; involucral bracts lanceolate or linear; capsule ovoid, $\frac{1}{2}$–$\frac{3}{4}$ in. long, seeds small, punctate. April–June. In dry woods; one of the most beautiful wild flowers.

97. EBENACEÆ. EBONY FAMILY.

Trees or shrubs; leaves simple, alternate, entire, exstipulate, petioled; flowers polygamous, diœcious or rarely perfect, the staminate cymose, the pistillate axillary and solitary; calyx free from the ovary, 3–7-lobed, persistent; corolla 3-7-lobed, deciduous; stamens 15–20 in the staminate flowers, inserted on the base of the corolla, often in pairs; usually a few abortive stamens in the pistillate flowers; ovary superior, several-celled, 1–3 ovules in each cell, styles 2–8, distinct or united below; fruit fleshy, several-seeded.

DIOSPYROS.

Trees or shrubs; leaves broad; flowers lateral; calyx 4–6-lobed, persistent, becoming enlarged and thickened in fruit; corolla bell-shaped, 4–6-cleft; stamens usually 16 in the staminate flowers; styles in the pistillate flowers 2–4, united below, cells of the ovary double the number of the styles; fruit pulpy, with several large, flat seeds.

D. Virginiana L. Persimmon. Trees, with rough, black bark and very hard wood; leaves oval or ovate-oblong, acute or

acuminate at the apex, rounded or slightly cordate at the base, entire, smooth and dark green above, pale and often pubescent beneath, short-petioled, deciduous; flowers yellowish-white, the parts mostly in 4's; fruit globose, edible when ripe, very astringent when green; seeds large, compressed, often wanting. May–June. Fruit ripening late in the fall; very common.

98. **SYMPLOCACEÆ.** SWEET–LEAF FAMILY.

Trees or shrubs; leaves simple, alternate, petioled, exstipulate; flowers in sessile axillary clusters; calyx tube partially adherent to the ovary, 5-lobed; corolla 5-lobed; stamens very numerous, usually somewhat united in clusters, filaments filiform; ovary 2–5-celled, ovules 2 in each cell, style slender, stigma entire or 3–5-lobed; fruit a small drupe or berry, 1–5-seeded.

SYMPLOCOS.

Characters of the family.

S. TINCTORIA (L.) L'Her. SWEET LEAF. A shrub or small tree; leaves alternate, coriaceous, oval or oblong, acute at each end, crenate-dentate, pubescent when young, becoming smooth above, somewhat evergreen, sweet to the taste; petioles short, pubescent; flower clusters sessile, scaly-bracted; flowers light yellow; calyx smooth, top-shaped; stamens in 5 sets; stigma entire; fruit becoming nearly dry, 1-seeded. March–April. Banks of streams and low woods.

99. **STYRACACEÆ.** STORAX FAMILY.

Trees or shrubs; leaves simple, alternate, exstipulate; flowers regular, perfect, clustered or solitary; calyx more or less adherent to the ovary, 4–8-toothed or truncate; corolla hypogynous or inserted on the calyx, 4–8-lobed or sometimes polypetalous; stamens inserted on the base of the corolla, twice as many as its lobes or more numerous, distinct, monadelphous or polydelphous; ovary 2–5-celled, style slender, stigma simple or lobed; fruit berry-like or dry, 1–5-celled, one seed in each cell.

I. MOHRODENDRON.

Trees or shrubs; pubescence stellate; leaves ample, dentate, petioled; flowers in short lateral racemes or clusters, white, bell-shaped, drooping on slender pedicels, appearing with or before the leaves; calyx obconic, obscurely 4-toothed, aduate to the ovary, teeth persistent; corolla 4-lobed or 4-petalous; stamens 8–16, filaments flat, distinct or united below; the short style persistent, ovary 2–4-celled, ovules 4 in each cell; fruit dry, prominently 2–4-winged, 1–3-seeded.

1. M. DIPTERUM (Ell.) Britt. TWO-WINGED SILVER-BELL. A small tree; leaves oval, serrate, pubescent, 4–6 in. long; racemes 2–4-flowered; flowers white, 1 in. wide, on long and slender pedicels; petals 4, nearly or quite distinct; stamens 8, distinct, anthers spreading; ovary 3-celled; fruit compressed, 2-winged, 1 in. long. March–April. In rich woods.

2. M. CAROLINIANUM (L.) Britt. FOUR-WINGED SILVER-BELL. Small trees; leaves oval to ovate-oblong, finely serrate, pubescent when young, becoming smooth when old, 2–4 in. long; flowers 2–4 in a cluster, pedicels long and slender; corolla 4-lobed; stamens mostly 12, united below the middle, anthers erect; ovary 4-celled; fruit 1–1½ in. long, exceeding the pedicel, prominently 4-winged. March–April. River banks.

II. STYRAX.

Shrubs; pubescence downy or scurfy-stellate; leaves alternate, entire or toothed, deciduous; flowers white, in leafy racemes; calyx tube 5-toothed, slightly coherent with the base of the ovary; corolla 5-parted, the lobes spreading or reflexed; stamens 10, inserted on the base of the corolla, distinct, or monadelphous below; ovary 3-celled, style filiform, stigma 3-lobed; fruit a globose, 3-valved, 1-seeded capsule.

1. S. AMERICANA Lam. SMOOTH STORAX. A shrub 4–8 ft. high; leaves ovate to obovate, usually acute at both ends, entire or few-toothed, thin, smooth when old, often scurfy below when young; flowers solitary or in 4–6-flowered, scurfy racemes, pedicels slender; calyx teeth short, subulate; pedicels and calyx glandular-dotted; fruit globose, puberulent, ¼ in. in diameter. March–May. Banks of streams.

2. S. PULVERULENTA Michx. DOWNY STORAX. A shrub 4–6 ft. high; leaves elliptical to obovate, acute at each end, entire or slightly toothed, the lower surface as well as the twigs, pedicels and calyx densely scurfy or stellate-pubescent; racemes short, terminal or axillary, pedicels short; flowers fragrant; calyx teeth subulate; fruit globose, puberulent. March–April. Pine-barren swamps.

3. S. GRANDIFLORA Ait. LARGE-LEAVED STORAX. A shrub 4–10 ft. high; leaves large, 3–6 in. long, obovate or oval, acute at each end, entire or coarsely toothed, smooth above, white-tomentose below; petioles short; racemes many-flowered, flowers longer than the pedicels; calyx furrowed, teeth triangular, acute; fruit obovoid, puberulent. March–May. In rich woods.

100. OLEACEÆ. OLIVE FAMILY.

Trees or shrubs; leaves opposite, simple or compound, exstipulate, deciduous or evergreen; flowers in terminal or axillary clusters, perfect, polygamous or diœcious; calyx small, 4-parted, free from the ovary, or none; corolla 4-lobed, or 4-petalous, or wanting; stamens 2–4, distinct; ovary 2-celled, 2 ovules in each cell, style usually short or none; fruit a 1–2-seeded capsule, samara, drupe or berry.

I. FRAXINUS.

Trees; leaves petioled, compound, odd-pinnate, deciduous; flowers in racemes or fascicles from buds of the previous season, polygamous or diœcious; calyx minutely 4-toothed, or wanting; corolla usually wanting; stamens 2–4, hypogynous, anthers longer than the filaments; stigma 2-cleft; fruit a 1–2-seeded samara winged at the apex.

1. F. AMERICANA L. WHITE ASH. A large tree; bark rough, gray, wood hard, strong, elastic; twigs and petioles glabrous; leaflets usually 7, ovate to ovate-lanceolate, acuminate at the apex, rounded or obtuse at the base, entire or slightly serrate, smooth above, often pubescent beneath, short-stalked; flowers mostly diœcious; calyx of the pistillate flowers persistent; samara $1\frac{1}{2}$–2 in. long, winged only at the apex, wing spatulate or oblanceolate. April–May. In rich woods and swamps.

2. F. PENNSYLVANICA Marsh. RED ASH. A small tree; bark rough, dark gray; twigs and petioles densely velvety-pubescent;

leaflets 5–9, oblong-ovate to ovate-lanceolate, acuminate at the apex, narrowed into a short stalk at the base, finely serrate, smooth above, velvety-pubescent beneath; calyx of the pistillate flowers persistent; samara $1\frac{1}{2}$–2 in. long, the wing somewhat decurrent along the sides, oblanceolate or spatulate, often notched. March–April. Swamps and moist soil.

3. F. Caroliniana Mill. Water Ash. A small tree; wood soft, light and weak; twigs smooth or pubescent; leaflets 5–7, ovate or elliptical, acute at the apex, acute or obtuse at the base, entire or slightly serrate, smooth or slightly pubescent, stalked; flowers diœcious; calyx persistent; samara often 3-angled or 3-winged, wings decurrent nearly to the base, oblong or oval, pinnately veined. March–April. In swamps and wet soil.

II. CHIONANTHUS.

Shrubs or small trees; leaves simple, opposite, entire, petioled, deciduous; flowers in panicles borne on wood of the previous season; calyx small, 4-cleft, persistent; corolla wheel-shaped, 4-parted, the lobes long and linear; stamens 2–4, included, inserted on the base of the corolla; style short, stigma 2-lobed; fruit a 1-seeded drupe.

C. Virginica L. Fringe-tree. A small tree, with smooth, light gray bark and spreading branches; leaves oval to oblong, acute or obtuse at each end, smooth or slightly pubescent; panicles large and loose, leafy-bracted, appearing with the leaves; flowers on slender, drooping pedicels; petals 1 in. or more in length; drupe ovoid, purple, $\frac{1}{2}$–$\frac{2}{3}$ in. long. April–May. Along streams, usually on light soil.

III. LIGUSTRUM.

Shrubs; leaves simple, opposite, entire, deciduous or sometimes persistent; flowers in terminal panicles or thyrses, white, small; calyx minutely 4-toothed or truncate; corolla funnel-form, 4-lobed; stamens 2, short, inserted in the tube of the corolla; ovary free, 2-celled, 2 ovules in each cell, style short; fruit a 1–4-seeded, globose berry.

L. vulgare L. Privet. A branching shrub 4–10 ft. high; branches long and slender; leaves somewhat coriaceous, lanceolate to obovate, short-petioled, tardily deciduous; panicles dense, minutely pubescent; flowers fragrant, $\frac{1}{4}$ in. wide; stamens included; berries black. April–June. Introduced from Europe and used largely for hedges.

IV. OLEA.

Trees or shrubs; leaves evergreen, opposite, simple, coriaceous; flowers in axillary racemes or panicles, fragrant; calyx 4-toothed, persistent; corolla short-salver-form, 4-lobed; stamens 2, exserted; stigma globose or 2-lobed; fruit a 1–2-seeded drupe.

1. O. Americana L. American Olive. A small tree; bark smooth, light gray; leaves thick, elliptical to obovate, petioled, entire, smooth and shining; racemes axillary, shorter than the leaves; flowers polygamous or diœcious, bracted; drupe ovoid, dark purple, bitter and astringent. March–April. Along streams and margins of swamps; more abundant near the coast.

2. O. fragrans Thunb. Sweet Olive. A small tree; leaves thick, lanceolate-oblong, petioled, serrate, smooth and shining; flowers in axillary corymbs, white or pink, very fragrant; drupe globose, black. March–May. Introduced from China and widely cultivated.

101. LOGANIACEÆ. LOGANIA FAMILY.

Herbs, shrubs or twining vines; leaves simple, opposite, connate, or the bases connected by a stipular line; flowers perfect, regular, in spikes or cymes, or axillary and solitary; calyx tube free from the ovary, 4–5-lobed; corolla tubular to campanulate; stamens as many as the lobes of the corolla and inserted in the tube; ovary mostly 2-celled, style single, stigma 2–5-cleft; fruit a 2-valved, few- or many-seeded capsule.

I. GELSEMIUM.

Twining woody vines; leaves evergreen, opposite, bases connected by a stipular line; flowers in bracted axillary or terminal cymes; pedicels scaly-bracted; calyx 5-parted, persistent; corolla funnel-form, 5-lobed, the lobes rounded; stamens 5, inserted near the base of the corolla tube, anthers oblong-sagittate; ovary 2-celled, style 1, deeply 4-parted; fruit an oblong, compressed, 2-celled capsule, seeds several, flattened and winged.

G. SEMPERVIRENS (L.) Ait. YELLOW JESSAMINE. Stem smooth, twining high; young branches purple; leaves lanceolate to ovate, acuminate at the apex, acute to slightly cordate at the base, entire, coriaceous; flowers $1\frac{1}{2}$ in. long, bright yellow, fragrant, of two forms, in one of which the anthers are exserted and the style included, while in the other the anthers are included and style long; pedicels short; capsule flattened contrary to the partition, seeds oval, winged at the apex. March–April. Woods and river banks.

II. SPIGELIA.

Herbs; leaves opposite, entire; flowers in one-sided, scorpioid spikes, or rarely solitary; calyx 5-parted, its lobes slender, persistent; corolla tubular-funnel form, 5-lobed, the tube many-nerved; stamens 5, inserted in the tube of the corolla, anthers linear; style slender, jointed in the middle, bearded above, stigma capitate, ovary 2-celled, ovules many; fruit a capsule, few-seeded, seeds not winged.

S. MARILANDICA L. PINKROOT. Perennial; stem simple, erect, smooth, 4-angled, 1–2 ft. high; leaves ovate to ovate-lanceolate, acute at the apex, rounded or sessile at the base, smooth above, pubescent on the veins beneath; spikes terminal, many-flowered, sometimes forking, bracted below the short pedicels; corolla $1\frac{1}{2}$–2 in. long, dark red outside, yellow within, lobes lanceolate, spreading; anthers and style exserted; capsule somewhat flattened, seeds flattened, orbicular. May–June. In rich woods.

102. GENTIANACEÆ. GENTIAN FAMILY.

Herbs; mostly with a bitter juice; stem smooth; leaves simple, opposite or verticillate, exstipulate, entire; flowers perfect, regular, terminal or axillary, clustered or solitary; calyx 2–12-parted, persistent; corolla 4–12-lobed; stamens as many as the lobes of the corolla and inserted in its lobes or throat; ovary superior, 1- or partly 2-celled, ovules numerous, attached to parietal placentæ, style simple or none, stigma entire or 2-lobed; fruit a 1-celled, or imperfectly 2–4-celled capsule dehiscent by 2 valves.

I. SABBATIA.

Annual or biennial herbs; stems erect, glabrous, branching, often angled; leaves opposite or verticillate, sessile or rarely petioled; flowers terminal, white or red, solitary or cymose; calyx 4–12-parted, the tube usually very short, the lobes long and narrow; corolla wheel-shaped, deeply 4–12-parted; stamens 5–12 and inserted on the throat of the corolla, anthers slender, curved; ovary 1-celled, style with filiform lobes, twisted; capsule globose, 2-valved, many-seeded, seeds reticulated.

1. S. MACROPHYLLA Hook. LARGE-LEAVED SABBATIA. Biennial; stem erect, glaucous, rigid, hollow, corymbosely branched above, 2–3 ft. high; leaves opposite, thick, ovate-lanceolate, acute at the apex, clasping at the base, strongly 3–5-nerved; flowers in large, flat-topped cymes, white, $\frac{1}{2}$ in. wide; calyx 5-parted, the lobes bristle-like, one-third the length of the lobes of the corolla. June–August. Low pine barrens, more common southward.

2. S. ANGULARIS (L.) Pursh. BITTERBLOOM. Annual; stem erect, square, wing-angled, smooth, widely branched, 1–2 ft. high; lower branches sometimes alternate, the others opposite; leaves numerous, ovate, acute, cordate-clasping at the base, 3–5-nerved, about as long as the joints; flowers in a panicled cyme, about 1 in. wide, rose color or purple; calyx lobes 5, linear, about half the length of the obovate corolla lobes; style 2-cleft; capsule ovoid, about the length of the calyx lobes. July–August. On low rich soil.

3. S. STELLARIS Pursh. MARSH PINK. Stem obscurely 4-angled, widely branched, smooth, 1–2 ft. high; branches all alternate; leaves thick or somewhat fleshy, the lower spatulate, the upper lanceolate-oblong or linear, sessile; flowers on long peduncles, 1–1$\frac{1}{2}$ in. wide, pink to white, with a yellow eye; calyx lobes linear, shorter than the obovate divisions of the corolla; style deeply 2-cleft; capsule ovoid. June–September. In salt marshes.

4. S. CAMPANULATA (L.) Torr. SLENDER MARSH PINK. Stem obscurely 4-angled, slender; the branches alternate and diffuse; leaves linear, the upper filiform, and the lower broader and obtuse, sessile, 1–1$\frac{1}{2}$ in. long; flowers on rather short peduncles, pink with a yellow eye, 1–1$\frac{1}{4}$ in. wide; calyx lobes linear, as long as the oblong-obovate divisions of the corolla; style 2-cleft; capsule obovoid, about half the length of the calyx lobes. May–August. Low pine barrens and brackish marshes.

5. S. GENTIANOIDES Ell. PINE-WOODS PINK. Stem erect, smooth, simple, or few-branched above, 9–15 in. high; leaves oblanceolate or

oblong, narrowed at the base, the upper linear, sessile; flowers terminal, sometimes 2–3 together on short peduncles, 2-bracted; calyx lobes 7–12, narrowly lanceolate; corolla 7–12-parted, bright rose color, 1½–2 in. wide; anthers straight. June–August. Low pine barrens.

II. GENTIANA.

Annual or perennial herbs, mostly blooming after midsummer; leaves opposite or verticillate, sessile or short-petioled; flowers showy, solitary or clustered, terminal or axillary; calyx tubular, 4–5-parted; corolla tubular, funnel-form or salver-form, 4–5-lobed, often with plaited and toothed folds between the lobes; stamens 4–5, alternate with the lobes of the corolla and inserted in the tube, distinct or united by the anthers, included; ovary 1-celled, styles short or none, stigmas 2; fruit a 1-celled, 2-valved, many-seeded capsule.

1. G. ELLIOTTII Chap. ELLIOTT'S GENTIAN. Perennial; stem erect, slender, somewhat rough-pubescent, 6–18 in. high; leaves ovate to narrowly lanceolate, acute at the apex, rounded and clasping at the base, rough-margined, 3-nerved; flowers in terminal and axillary clusters, about 2 in. long, sessile or nearly so, 2-bracted; calyx lobes oblong, twice as long as the tube; corolla funnel-form, bright blue without, deep blue and yellow within, the lobes short, ovate, obtuse, folds between the lobes 2-toothed and fimbriate; anthers cohering in a tube; seeds oblong, winged; plant quite variable. September–October. In moist soil.

2. G. PORPHYRIO Gmel. NARROW-LEAVED GENTIAN. Perennial; stem erect, glabrous, simple or branched, 4–15 in. high; leaves opposite, linear and somewhat fleshy; flowers terminal, solitary; calyx lobes linear, erect, a little longer than the tube; corolla spreading, funnel-form, bright blue, 1½–2 in. long, the lobes ovate, acute, two or three times as long as the laciniate folds; anthers not united; seeds oblong, wingless. August–October. Moist pine barrens.

III. FRASERA.

Perennial or biennial herbs; stems mostly tall and glabrous; leaves opposite or verticillate, sessile; flowers in terminal, cymose panicles or thyrses; calyx 4-parted; corolla 4-parted, the lobes spreading and bearing 1 or 2 fringed glands upon the upper face; stamens 4, inserted in the tube of the corolla; ovary 1-celled, style usually short, persistent,

stigmas entire or 2-lobed; fruit an ovoid, compressed, 2-valved, few-seeded capsule.

F. CAROLINENSIS Walt. AMERICAN COLUMBO. Perennial, root large, bitter; stem erect, stout, 4–8 ft. high; leaves in whorls of 4–6, the lower spatulate or oblanceolate, the upper elliptical, becoming small and bract-like near the summit of the stem; flowering branches in whorls of 4, forming a large pyramidal panicle; pedicels slender; flowers about 1 in. wide; corolla rotate, yellowish-white with numerous brownish-purple spots, lobes oblong, with a large fringed gland near the middle; capsule ovoid, longer than the calyx; seeds flattened, winged. June–August. In rich and dry woods.

103. APOCYNACEÆ. DOGBANE FAMILY.

Perennial herbs or shrubs, with acrid milky juice; leaves simple, alternate, opposite or verticillate, exstipulate; flowers perfect, regular, solitary, cymose or paniculate; calyx 5-parted, persistent; corolla bell-shaped to salver-form, convolute in the bud; stamens 5, inserted in the tube of the corolla and alternate with its lobes; ovary superior, usually of 2 distinct carpels united by the style, sometimes 2-celled or 1-celled with 2 parietal placentæ, style simple or 2-parted; fruit usually 2 follicles, many-seeded, seeds often with a coma.

I. AMSONIA.

Perennial herbs; stem erect, branched; leaves alternate; flowers in terminal panicles; calyx small, 5-parted; corolla small, pale blue, funnel- or salver-form, pubescent within; stamens inserted above the middle of the tube, included; ovary of 2 carpels, united at the top by the slender style, stigma globose, surrounded by a cup-shaped appendage; fruit 2 slender, erect, many-seeded follicles, seeds not comose.

1. A. AMSONIA (L.) Britt. AMSONIA. Stem smooth and glabrous, branched above, 2–3 ft. high; leaves lanceolate, entire, acuminate at the apex, acute at the base, smooth above, glaucous or slightly pubescent beneath, short-petioled; flowers numerous, on bracted pedicels; corolla tube slender, smooth or sometimes pubescent above,

the lobes narrow, as long as the tube; follicles slender, spreading, 4–6 in. long, seeds pubescent. April–June. Swamps and wet ground.

2. A. ANGUSTIFOLIA Michx. NARROW-LEAVED AMSONIA. The whole plant villous when young, becoming smoother with age; stems finally much branched above, 2–3 ft. high; leaves crowded, linear or linear-lanceolate, fringed and revolute on the edges, almost sessile; corolla pale blue or white, funnel-form, smooth; follicles very slender, 2–5 in. long. April–May. On dry soil.

II. VINCA.

Erect or trailing herbs; juice only slightly milky; leaves opposite, entire, thick, smooth; flowers axillary; calyx tube short, obconic, lobes narrow, elongated; tube of the corolla with a callous ring at the throat, pubescent within, limb spreading, segments oblique; stamens 5, alternate with the lobes of the corolla, and inserted in the tube, included; disk of 2 glands alternate with the 2 carpels; style single, stigma enlarged; follicles erect or spreading, many-seeded, seeds not comose.

V. MINOR L. PERIWINKLE. Stem slender, trailing, often rooting at the nodes, 1–3 ft. long; leaves ovate, acute at the apex, short-petioled, bright green; flowers axillary, solitary, 1 in. wide; calyx with linear lobes nearly as long as the inflated tube of the blue corolla; matured follicles slender, slightly divergent. January–June. Introduced from Europe and common in gardens.

III. APOCYNUM.

Perennial herbs; stems with very tough bark, branched above; leaves opposite, entire; flowers in terminal and axillary bracted cymes; calyx small, 5-parted, lobes acute; corolla bell-shaped, 5-lobed, with a small scale-like appendage at the base of each lobe; stamens 5, distinct, inserted in the base of the corolla tube; ovaries 2, distinct, united by the styles, stigma obtuse, 2-lobed; follicles long, slender, many-seeded, seeds comose.

A. CANNABINUM L. INDIAN HEMP. Stem erect, smooth, with numerous erect or ascending branches; leaves oval to oblong, mucronate at the apex, rounded at the base, pubescent beneath, short-

petioled; cymes terminal, compact, shorter than the leaves; flowers on short, bracted pedicels, greenish-white, about $\frac{1}{4}$ in. broad; calyx lobes lanceolate, nearly as long as the tube of the corolla; corolla lobes erect; follicles very slender, tapering, 3–4 in. long. June–August. Along fences and in thickets.

IV. NERIUM.

Shrubs; leaves mostly verticillate in 3's; flowers in terminal cymes; calyx small, lobes acute; corolla salver-form, convolute, the throat of the tube crowned with cleft or fimbriate scales; stamens 5, short, included, anthers tipped with a hairy bristle; ovary of 2 carpels, style short; follicles erect, seeds comose.

N. Oleander L. Oleander. Stem erect, diffusely branched from below, 4–10 ft. high; leaves narrowly elliptical, acute at each end, thick and leathery, short-petioled; flowers showy, in large clusters, red or white, often double; scales of the crown 3–4-pointed unequal teeth; follicles fusiform, 3 4 in. long. April–November. Introduced from Palestine, common in cultivation and often spontaneous in the southern section.

104. ASCLEPIADACEÆ. MILKWEED FAMILY.

Herbs, twining vines or sometimes shrubby plants, with milky juice; leaves alternate, opposite or verticillate, exstipulate; flowers perfect, regular, in terminal and axillary cymes or umbels; calyx 5-parted, persistent, the tube short or none; corolla 5-parted, deciduous, rotate, campanulate or funnelform; stamens 5, inserted near the base of the corolla; filaments united into a tube (gymnostegium) enclosing the ovary, and bearing appendages which are often hood-like, and are termed the stamineal crown; anthers erect, 2-celled, the cells often with a thin membranous appendage at the apex or sometimes at the base; pollen masses waxy, usually 1 in each anther cell, attached in pairs and to the stigma by a connective stalk; ovary of 2 carpels, styles 2, united into a single fleshy stigma; fruit a many-seeded follicle, seeds usually

comose. Most species bloom late in the season. [The pollen masses are easily withdrawn from the anther-sacks, and are often found attached to the legs of insects which visit the flowers for nectar and fertilize the pistils in their struggles to free themselves from the sticky anthers.]

I. ASCLEPIAS.

Perennial herbs; stems erect or decumbent; leaves alternate, opposite or whorled; flowers in terminal or lateral umbels; calyx 5-parted, small, lobes acute; corolla rotate, deeply 5-parted, reflexed, crown of 5 hoods, each containing an incurved, horn-like appendage; anthers tipped with an inflexed membrane; pollen masses 10, each pair occupying the contiguous cells of adjacent anthers; follicles large, many-seeded, seeds flat, usually comose.

1. A. TUBEROSA L. BUTTERFLY-WEED. Stem stout, erect or ascending, branched above, hirsute, very leafy, 1–2 ft. high; leaves alternate or the lower opposite, oblong to lanceolate or linear, acute at the apex, rounded or cordate at the base, short-petioled, pubescent; umbels numerous, corymbose, many-flowered; peduncles shorter than the leaves; pedicels erect, about 1 in. long, pubescent; corolla yellowish-orange, crown bright orange, hoods erect, longer than the slender horns, and twice as long as the stamens; follicles erect, fusiform, pubescent, seeds comose. June–August. Common on dry soil.

2. A. VARIEGATA L. WHITE MILKWEED. Stem stout, leafless and smooth below, leafy and pubescent in lines above; leaves opposite, the middle ones sometimes in 4's, petioled, ovate to obovate, cuspidate, smooth on both sides, pale beneath, edges slightly crenate; umbels 1–5, compact, pubescent, 1–2 in. long; pedicels erect, as long as the peduncles; corolla white, often purple at the base; hoods roundish, spreading, longer than the purplish gymnostegium, and a little longer than the thick, awl-pointed, incurved horn; follicles erect, downy, seeds comose. May–June. Dry, open woods.

3. A. AMPLEXICAULIS Michx. PINE-BARREN ASCLEPIAS. Stems recurved, ascending or decumbent, smooth and glaucous, 1–2 ft. long; leaves opposite, very thick, ovate, obtuse at the apex, cordate and clasping at the base, veins white and prominent; umbels 3–6, many-flowered; peduncles half the length of the leaves, longer than the slender pedicels; corolla ash-colored; hoods white, longer than the

gymnostegium and the nearly straight horn; follicles ovate-lanceolate, seeds comose. April–May. Dry pine barrens.

4. A. PERENNIS Walt. THIN-LEAVED MILKWEED. Stem erect, branched, slender, shrubby at the base, pubescent in lines above, 1–3 ft. high; leaves opposite, petioled, thin, lanceolate to oblong-lanceolate, tapering at each end, smooth, pale beneath; umbels few, long-peduncled, often corymbose; pedicels slender, shorter than the peduncles; flowers small, white; hoods erect or spreading, about the length of the gymnostegium and half the length of the erect, needle-shaped horn; follicle erect, ovate-lanceolate, smooth, seeds ½ in. long, without coma. May–July. On river banks and in muddy places.

II. VINCETOXICUM.

Perennial; stems twining; leaves opposite, cordate, petioled; flowers in axillary umbels or corymbs; calyx 5-parted, the lobes spreading; corolla rotate, the tube very short, the lobes convolute in the bud; crown an entire or lobed ring, adnate to the throat of the corolla; stamens inserted in the base of the corolla, not appendaged; gymnostegium flattened, depressed; follicles inflated, smooth or armed with soft spines, seeds comose.

1. V. GONOCARPOS Walt. LARGE-LEAVED VINCETOXICUM. Stem slender, smooth or pubescent, twining high, 10–20 ft. long; leaves ovate, abruptly acuminate at the apex, deeply cordate at the base, 3–6 in. long; petioles 1–4 in. long; umbels peduncled, several-flowered; pedicels stout, spreading; flower buds conic; corolla greenish-purple, lobes lanceolate, obtuse, 3–4 times as long as the calyx, pubescent within; crown many-lobed; follicles smooth, 3–5-angled, 3–4 in. long. June–August. In moist thickets.

2. V. CAROLINENSE (Jacq.) Britt. CAROLINA VINCETOXICUM. Stem slender, hirsute, twining, 8–15 ft. long; leaves ovate, acuminate at the apex, deeply cordate at the base, 3–7 in. long; petiole 2–4 in. long; umbels on peduncles as long as the petioles, 6–8-flowered; flower buds ovate; corolla dark purple, the oblong lobes puberulent without, smooth within; crown 5-lobed with a 2-cleft tooth in each sinus; follicles warty. May–July. In woods.

105. CONVOLVULACEÆ. MORNING-GLORY FAMILY.

Annual or perennial herbs; stems usually twining or trailing, sometimes erect; leaves alternate, simple, exstipulate;

flowers regular, perfect, axillary, solitary or cymose; calyx 5-parted or 5-sepalous, usually persistent; corolla funnel-form or salver-form, 5-angled or 5-lobed, convolute; stamens 5, alternate with the lobes of the corolla, and inserted in its tube; ovary free, sessile, 2–3-celled with 2 ovules in each cell, or 4–6-celled with 1 ovule in each cell, styles 1–3, entire or 2-cleft; fruit a 1–6-seeded capsule.

I. DICHONDRA.

Perennial creeping herbs, rooting at the nodes; leaves cordate or reniform, petioled; flowers solitary, perfect, on bractless peduncles shorter than the leaves; calyx 5-parted, lobes narrowly obovate or spatulate; corolla rotate or open funnel-form, 5-lobed, shorter than the calyx; stamens 5, included; ovary deeply 2-parted, 4-celled, styles 2, stigmas capitate; fruit 2 distinct capsules, each 1–2-seeded.

D. EVOLVULACEA (L.) Britt. DICHONDRA. Stems slender, pubescent, 6–15 in. long; leaves deeply cordate or reniform, palmately veined; petiole 1–3 in. long; flowers small, greenish-yellow, less than $\frac{1}{4}$ in. wide; peduncles slender, erect; calyx silky-pubescent, lobes of the corolla obovate or spatulate; capsule small, pubescent, seeds smooth. March–October. On damp soil.

II. BREWERIA.

Perennial trailing herbs; stem slender, pubescent; leaves entire, sessile or short-petioled; flowers small, on axillary peduncles longer than the leaves; sepals 5; corolla white or yellow, bell-shaped, hairy, 5-lobed or angled; stamens included; ovary 2-celled, 4-ovuled, styles 2, distinct or united below, stigmas peltate; fruit a 1–4-seeded capsule.

B. HUMISTRATA (Walt.) Gr. BREWERIA. Stem slender, pubescent or rough-hairy, branching, 1–3 ft. long; leaves oblong to elliptical, acute, obtuse or emarginate and mucronate at the apex, rounded or cordate at the base, pubescent; petiole short; peduncles very slender, 1–7-flowered, minutely bracted above; sepals ovate, usually smooth, fringed on the margins; corolla white; filaments hairy; style 2-cleft; capsule ovoid, as long as the calyx, mostly 1-seeded. May–September. In dry woods.

III. QUAMOCLIT.

Annual herbs; stems slender, twining; leaves petioled, entire or pinnatifid; flowers solitary or clustered on axillary peduncles; sepals 5, short-awned or awnless; corolla salver-form, the tube long and somewhat enlarged above; stamens inserted in the base of the tube, exserted, filaments dilated below; ovary 4-celled, style 1, stigma globose, 2-lobed; fruit a 4-celled, 4-seeded capsule.

1. Q. Quamoclit (L.) Britt. Cypress Vine. Stem slender, smooth, twining high; leaves dark green, pinnatifid, the divisions linear, smooth; peduncles slender, as long as the leaves, 1–5-flowered; pedicels thickened upward; sepals ovate or oblong, mucronate; corolla bright scarlet or sometimes yellowish-white, salver-form, the tube 1–1½ in. long, the limb flat and spreading, ½–¾ in. wide; stamens and style exserted; capsule ovoid, twice the length of the sepals. May–October. Common in gardens.

2. Q. coccinea (L.) Moench. Small Red Morning-glory. Stems twining or trailing, smooth or pubescent; leaves cordate, acuminate at the apex, basal lobes somewhat angled; petiole slender, nearly as long as the blade; peduncles 3–5-flowered, longer than the petioles; sepals awned; corolla salver-form, slightly lobed, scarlet, sometimes yellowish, 1 in. long; capsule globose, as long as the sepals. June–September. Usually in cultivated ground.

IV. IPOMŒA.

Annual or perennial herbs; stems twining or trailing, or rarely erect; leaves from sagittate or cordate to nearly linear; flowers showy, white or purple, axillary, solitary, or in few-flowered cymes; sepals 5, sometimes unequal; corolla bell-shaped or funnel-form, 5-plaited and convolute in the bud, the limb entire, 5-angled or 5-lobed; stamens included, often unequal; ovary 2 4-celled, style slender, included, stigmas capitate, 2-lobed; fruit a 1–4-seeded capsule, seeds smooth or hairy.

1. I. pandurata (L.) Meyer. Wild Potato Vine. Perennial, from a very large tuberous root; stem trailing or twining, smooth or slightly pubescent, 5–10 ft. long; leaves broadly cordate, with the apex slender and obtuse, sometimes fiddle-shaped or 3-lobed; petioles slender; peduncles longer than the petioles, 1–5-flowered; sepals oblong, obtuse, smooth, mucronate, the 2 outer ones shorter; corolla white

with a purple throat, 2–3 in. wide, lobes pointed; capsule globose, 2–3-seeded, the seeds woolly on the angles. May–September. On dry or damp sandy soil.

2. I. TAMNIFOLIA L. BLUE BINDWEED. Annual; stem at first stout and erect, becoming slender and twining above, hirsute, 1–6 ft. long; leaves cordate or ovate, acuminate, long-petioled, hairy; peduncles longer than the petioles; flowers in crowded capitate cymes; bracts numerous, longer than the flowers; sepals subulate, bristly, as long as the corolla; corolla bright blue, ½ in. wide; fruit a depressed, slightly 4-angled capsule, seeds rough. May–September. Common in cultivated ground.

3. I. PURPUREA (L.) Roth. MORNING-GLORY. Annual; stem twining high, pubescent with reflexed hairs; leaves cordate, entire, pubescent, long-petioled; peduncles becoming elongated, 2–5 in. long, 1–5-flowered; pedicels twice the length of the calyx, reflexed in fruit; sepals lanceolate, pubescent; corolla 2 in. or more in length, white, blue, red or variegated, closing in sunshine; ovary 3-celled; capsule globose, shorter than the sepals. May–October. Common in cultivation.

4. I. SAGITTATA Cav. MARSH MORNING-GLORY. Perennial, from thick, fibrous roots; stem trailing, smooth, somewhat fleshy, 3–6 ft. long; leaves narrowly sagittate, basal lobes elongated, lanceolate or linear, smooth; peduncles shorter than the leaves, enlarged above, 1–3-flowered, bracts small; sepals oval, purple at the apex; corolla pink-purple, 2½–3 in. long; capsule ovoid, pointed, longer than the sepals, seeds silky on the angles. June-September. On damp soil, very common near the coast.

V. CONVOLVULUS.

Perennial herbs; stem twining, trailing or erect; leaves oval to cordate or sagittate, petioled; peduncles axillary, 1–few-flowered; flowers often with 2 large bracts at the base; sepals 5, the 2 outer ones longer; corolla bell-shaped, 5-lobed or 5-angled; stamens included; style filiform, stigmas 2, oblong or linear; fruit a globose, 1–4-celled, 1–4-seeded capsule, seeds smooth.

C. SEPIUM L. BINDWEED. Stem smooth, slender, twining or trailing, 3–10 ft. long; leaves broadly sagittate or hastate, acute, the basal lobes spreading, obliquely truncate or angled, dentate or entire; petioles 1–2 in. long; peduncles 4-angled, longer than the petioles, 1-flowered; bracts cordate-ovate, keeled on the back; sepals acute; corolla white or pink, 1½–2 in. long. June–September. Common in cultivated fields.

106. POLEMONIACEÆ. PHLOX FAMILY.

Annual, perennial or slightly shrubby plants; leaves opposite or alternate; flowers perfect, regular, solitary, cymose or paniculate; calyx 5-parted, the lobes scarious-margined; corolla rotate to funnel-form or salver-form, convolute in the bud, the limb 5-lobed or parted; stamens 5, inserted in the tube of the corolla and alternate with its lobes, filaments slender; ovary free, 3-celled, 3-many-ovuled, style single, filiform, 3-cleft; fruit a 3-celled, 3-valved, 3-many-seeded capsule, seeds angled.

I. PHLOX.

Perennial or rarely annual herbs; stems erect or diffuse; leaves opposite, or the upper alternate, entire, exstipulate; flowers showy, white or purple, in terminal cymes or panicles; calyx cylindrical or funnel-form, 5-cleft, the lobes acute; corolla salver-form, the tube long and slender, the limb 5-parted, the lobes spreading, entire or obcordate; stamens included, unequal; ovary 3-celled, style slender; capsule ovoid, 3-celled, 1-few-seeded, seeds wingless or narrow-winged.

1. P. PANICULATA L. GARDEN PHLOX. Perennial; stems in clumps, stout, erect, simple or branched above, 2-4 ft. high; leaves ovate-lanceolate to oblong, acuminate at the apex, rounded or cordate at the base, thin, smooth, veins prominent beneath; cymes numerous and compact, forming a pyramidal panicle; pedicels short; calyx teeth long, bristle-pointed; corolla purple to white, lobes round-obovate, shorter than the tube; capsule longer than the calyx tube. May-July. In rich woods; often cultivated.

2. P. PILOSA L. DOWNY PHLOX. Perennial; stem erect, slender, simple or branched, 1-2 ft. high; leaves linear-lanceolate to linear, distant, spreading, long-acuminate, sessile, stem and leaves pubescent or villous; cymes corymbose, loose; flowers short-pediceled; calyx glandular-viscid, the teeth shorter than the tube of the purple corolla, bristle-pointed; corolla tube pubescent, lobes obovate; capsule twice the length of the calyx tube. April-May. In dry, open woods.

3. P. DIVARICATA L. WILD BLUE PHLOX. Perennial; stems erect or ascending from a decumbent base, viscid-pubescent, 1 ft. high; leaves distant, lanceolate to oblong, acute at the apex, rounded at the base, sessile, pubescent; cymes corymbed, loosely flowered; calyx teeth subulate, longer than the tube; corolla bluish-purple, $\frac{1}{2}$–$\frac{3}{4}$ in. long, lobes notched at the apex, as long as the tube; capsule oval, shorter than the calyx teeth. April–May. In moist, open woods.

4. P. DRUMMONDII Hook. DRUMMOND'S PHLOX. Annual; stem erect or ascending, slender, weak, branching, glandular-pubescent, 6–12 in. high; leaves mostly alternate, lanceolate to oblong, pubescent, the upper clasping by a cordate base; corymbs loose; flowers rather long-pediceled; calyx tube short, the teeth lanceolate-setaceous, soon recurved; corolla purple to crimson or white, orifice of the tube usually with a white or yellowish star-like ring, lobes rounded at the apex; ovary 3-seeded, angles of the seeds winged. April–June. Introduced from Texas and common everywhere in gardens.

II. GILIA.

Annual, biennial or perennial herbs; leaves opposite or alternate, entire or much divided; flowers solitary or clustered; calyx tubular or bell-shaped, 5-cleft; corolla tubular to salver-form, 5-lobed; stamens inserted evenly or unevenly, near the mouth of the tube, included or exserted; ovary 3-celled, 3–many-ovuled, style long, slender, stigma 3-lobed; fruit a 3-celled, 3-many-seeded capsule, seeds angled or compressed.

G. RUBRA (L.) Heller. SCARLET GILIA. Biennial; stem erect, simple, smooth or pubescent, very leafy, 2–5 ft. high; leaves pinnately divided into filiform, acute segments; flowers very numerous in a long and slender panicle; calyx lobes setaceous-subulate, as long as the tube; corolla funnel-form, bright scarlet without, yellow spotted with red within, 1–1$\frac{1}{2}$ in. long, lobes acute, spreading, less than half the length of the tube; stamens slightly exserted; seeds with a loose, reticulated outer coat. June–September. Dry, sandy soil.

III. POLEMONIUM.

Perennial or annual herbs; stems erect or diffuse; leaves alternate, pinnately divided; flowers in a cyme or panicle; calyx bell-shaped, 5-cleft, becoming enlarged in fruit, the

lobes as long as the tube; corolla rotate to bell-shaped, 5-lobed; stamens 5, equally inserted in the throat of the tube, declined, filaments hairy at the base; ovary ovoid, ovules several; fruit a 3-celled, several-seeded capsule, seeds angled.

P. REPTANS L. GREEK VALERIAN. Perennial, from a short rootstock; stem smooth, weak, diffusely branched, 9–12 in. high; leaves petioled, odd-pinnate; leaflets 5–13, ovate to elliptical, entire; corymbs peduncled, few-flowered; flowers nodding, blue, ½ in. wide; stamens white, included. April–May. Rich, shady woods.

107. HYDROPHYLLACEÆ. WATER-LEAF FAMILY.

Annual, biennial or perennial herbs; leaves usually alternate, sometimes opposite, pinnately or palmately divided; flowers regular, perfect, solitary or in one-sided spikes or racemes; calyx 5-parted, persistent, often with reflexed appendages in the sinuses; corolla rotate to funnel-form or salver-form, 5-lobed; stamens 5, inserted in the base of the corolla and alternate with its lobes, filaments filiform, anthers versatile; ovary free, 1-celled with 2 parietal placentæ, or 2-celled, styles 2, distinct or united; fruit a globose or oblong, 2-celled, 2-valved, few–many-seeded capsule, seeds angular, reticulated.

I. HYDROPHYLLUM.

Biennial or perennial herbs; stem erect, hairy or pubescent; leaves alternate, long-petioled; flowers in peduncled cymes, bractless; calyx tubular, 5-cleft, with linear appendages on the tube; corolla broadly tubular or campanulate, 5-lobed, the lobes appendaged within; stamens 5, exserted, filaments hairy below; ovary hispid, 1-celled, with 2 thick fleshy placentæ, 4-ovuled, style single, 2-cleft; fruit a globose, 2-valved, 1–4-seeded capsule.

H. MACROPHYLLUM Nutt. LARGE-LEAVED WATER-LEAF. Perennial, from a scaly rootstock; stems stout, erect, hairy, 2–3 ft. high; leaves pinnately divided or pinnatifid, the divisions irregularly

toothed, the upper divisions larger; the lower leaves long-petioled, the upper nearly sessile; cymes simple or forked, compact; peduncle stout; pedicels short; calyx lobes longer than the tube, hispid; corolla nearly white; capsule hispid, globose, shorter than the calyx. April–June. In rich woods.

II. NEMOPHILA.

Annual; stems slender, decumbent, pubescent; leaves alternate or opposite, lobed or divided; flowers solitary, on peduncles opposite the petioles; calyx 5-parted, with reflexed appendages to the sinuses; corolla bell-shaped or tubular, 5-lobed, with 10 scale-like appendages at the base within; stamens 5, included; ovary hispid, 1-celled, placentæ 2, ovules 2–12; fruit a globose, 1–2-seeded capsule.

N. MICROCALYX (Nutt.) F. & M. SMALL-FLOWERED NEMOPHILA. Stem very slender, diffusely branched, pubescent, becoming smooth with age, 3–18 in. long; leaves alternate, or the lower opposite, long-petioled, deeply 3–5-parted, the lobes obovate, toothed; flowers small, white, peduncles slender, shorter than the petioles; appendages of the calyx and corolla minute; capsule longer than the calyx, 1–2-seeded, seeds bony. April–June. In shady woods.

III. NAMA.

Perennial herbs; stem glandular-pubescent or bristly; leaves alternate, entire, often with spines in the axils; flowers regular, perfect, axillary or terminal, solitary or clustered; calyx 5-parted or 5-sepalous; corolla bell-shaped, 5-parted; stamens 5, inserted on the base of the corolla, and alternate with its lobes, filaments dilated below; ovary 2-celled, many-ovuled, styles 2, distinct, slender; fruit a globose, 2-celled, several-seeded capsule.

1. N. QUADRIVALVIS (Walt.) Kuntze. HAIRY NAMA. Stem ascending or erect, from a creeping base, pubescent or hispid, mostly simple, 1–3 ft. high; leaves lanceolate, acute at the apex, narrowed into a petiole below, pubescent on the veins beneath, axils spiny; flowers axillary, solitary or clustered, short-peduncled; calyx lobes linear, as long as the corolla; stamens included; capsule apparently 4-celled by the thickening of the placentæ, 2-valved, as long as the calyx. June–August. In muddy places.

2. N. OVATA (Nutt.) Britt. OVATE-LEAVED NAMA. Stem erect, pubescent, spiny, simple or branched above, 2–3 ft. high; leaves ovate, short-petioled or the upper sessile, slightly pubescent; flowers blue, crowded at the ends of the branches; sepals lanceolate, hairy, shorter than the corolla; stamens and styles exserted; capsule shorter than the calyx. May–August. In wet soil.

108. BORAGINACEÆ. BORAGE FAMILY.

Annual, biennial or perennial herbs, or rarely shrubs; leaves usually alternate, rough-hairy and entire, exstipulate; flowers perfect, usually in one-sided coiled spikes or racemes; calyx 5-parted, persistent; corolla 5-lobed, hypogynous, often appendaged in the throat; stamens 5, inserted in the tube of the corolla and alternate with its lobes; ovary free, 2-celled, the cells deeply 2-lobed, making the ovary appear 4-celled, ovules 4, style single; fruit usually 4 nutlets, each 1-seeded.

I. HELIOTROPIUM.

Herbs or shrubs; leaves alternate, petioled, mostly entire; flowers white or blue, in one-sided scorpioid spikes; calyx lobes narrow; corolla funnel-form or salver-form, not appendaged in the throat, the tube folded between the lobes; stamens included, filaments short or none; stigma conical; ovary 4-grooved, separable into 4 nutlets.

1. H. CURASSAVICUM L. SEASIDE HELIOTROPE. Annual; stem succulent, glabrous and somewhat glaucous, diffusely branched, 6–18 in. long; leaves alternate or opposite, oblanceolate to linear, obtuse at the apex, narrowed below, entire, somewhat fleshy, the upper sessile and often fasciculate; spikes peduncled, often forked, densely flowered; flowers small, white, fading to blue, sessile, bractless; capsule globose, nutlets smooth; plant turning black in drying. May–September. In saline marshes.

2. H. INDICUM L. INDIAN HELIOTROPE. Annual; stem erect, rough-hairy or hispid, branched, 1–3 ft. high; leaves ovate to oblong, obtuse or acute at the apex, rounded or cordate at the base, wavy on the margin, rugose, decurrent on the petiole; spikes seldom forked, hairy, densely flowered, becoming 4–9 in. long; calyx lobes lanceolate, shorter than the hairy tube of the blue corolla; capsule smooth, nutlets finally spreading. May–October. In waste places.

II. CYNOGLOSSUM.

Biennial or perennial; stems pubescent or hispid; leaves alternate, the lower long-petioled, the upper sessile; flowers in panicled racemes; calyx 5-parted, enlarged and spreading in fruit; corolla funnel-form, with 5 obtuse scales closing the throat of the tube; stamens included; ovary 4-lobed, style slender; fruit 4 ovate nutlets which are covered with hooked or barbed bristles.

C. VIRGINICUM L. WILD COMFREY. Perennial; stem stout, simple, erect, leafless above, 2–3 ft. high; leaves oval or oblong, the upper clasping by a cordate base; racemes bractless; flowers pale blue, on short pedicels which are recurved in fruit; nutlets not margined, separating and falling away at maturity. April–June. On dry soil.

III. MYOSOTIS.

Low annual, biennial or perennial herbs; stems branching, erect or diffuse; leaves alternate, entire; flowers small, blue, pink or white, in elongated bractless racemes; calyx 5-cleft, the lobes erect or spreading in fruit; corolla salver-form, 5-lobed, the tube as long as the calyx, the throat with 5 small appendages; stamens 5, inserted in the tube of the corolla, included; ovary 4-parted, style slender; nutlets smooth or pubescent, elliptical, compressed.

1. M. PALUSTRIS (L.) Lam. FORGET-ME-NOT. Perennial, from slender rootstocks; stems slender, pubescent, rooting at the nodes, 6–15 in. long; leaves oblong to oblong-lanceolate, obtuse, narrowed to the sessile base, appressed-pubescent; racemes many-flowered; pedicels becoming elongated in fruit; lobes of the calyx shorter than the tube, spreading in fruit; corolla blue with a yellow eye; nutlets angled, smooth. April July. Common in gardens and often naturalized.

2. M. LAXA Lehm. SMALL FORGET-ME-NOT. Annual or perennial; whole plant pubescent; stem slender, weak, decumbent and rooting at the base, 1–2 ft. long; lower leaves spatulate, the upper lanceolate; racemes loosely flowered, becoming elongated in fruit; pedicels spreading; calyx hispid, the lobes as long as the tube; corolla pale blue with a yellow eye; nutlets convex on all sides. May–July. On low ground.

IV. LITHOSPERMUM.

Annual or perennial herbs, mostly rough-hairy, and with red roots; leaves alternate, entire; flowers in leafy-bracted spikes or racemes; calyx 5-parted, the lobes narrow, equal; corolla funnel-form to salver-form, obtusely 5-lobed, smooth, crested or hairy in the throat; stamens 5, inserted in the tube of the corolla, included; ovary deeply 4-parted, style slender, stigma capitate or 2-lobed; nutlets 1–4, white and smooth or brown and wrinkled, truncate at the base.

1. L. ARVENSE L. FIELD GROMWELL. Annual or biennial; rough with appressed hairs; stem erect, simple or branched from the base, 6–18 in. high; leaves lanceolate to linear, the lower obtuse at the apex and tapering into a short petiole, the upper acute and sessile; flowers scattering and sessile on the spikes; calyx lobes linear-subulate, as long as the yellowish-white, funnel-form corolla; nutlets brown, wrinkled and pitted, about one-half the length of the calyx. March–April. Fields and waste places.

2. L. GMELINI (Michx.) Hitch. HAIRY PUCCOON. Perennial; hispid with rigid hairs; stems usually clustered, erect, simple, or branched above, stout, 1–2 ft. high; leaves linear-lanceolate, obtuse, sessile, the lower often scale-like; flowers in leafy, terminal racemes; calyx lobes linear; corolla salver-form, orange-yellow, the tube $\frac{3}{4}$ in. long, twice the length of the calyx, hairy within, the lobes rounded, spreading, the throat crested; nutlets white, shining, ovoid. April–May. In dry pine barrens.

V. ONOSMODIUM.

Perennial, hispid herbs; stems stout; leaves alternate, entire, prominently veined; flowers greenish-white, on a terminal bracted spike or raceme; calyx 5-parted, lobes linear; corolla tubular, the 5 short, acute lobes connivent, tube 10-toothed within; stamens included, nearly sessile; style filiform, exserted, ovules 4; nutlets often only 1 or 2, white, ovoid, smooth and shining, or pitted.

1. O. CAROLINIANUM (Lam.) DC. CAROLINA GROMWELL. Stem stout, erect, branching, rough with rigid white hairs, 2–4 ft. high; leaves ovate-lanceolate to oblong, acute at the apex, sessile, 5–9-ribbed; flowers pediceled, yellowish-white; calyx about half the length of the corolla, which is pubescent on the outside; nutlets dull

white, about half the length of the calyx. May–June. In dry fields and thickets.

2. O. Virginianum (L.) DC. Virginia Gromwell. Stem erect, slender, sparingly branched above, rough with bristly hairs, 1–2 ft. high; leaves lanceolate to oblanceolate, obtuse at the apex, sessile; corolla yellowish-white, tubular, the lobes acute, nearly as long as the tube, bristly; nutlets white, shining, ovoid. May–June. In dry fields and woods.

109. VERBENACEÆ. VERBENA FAMILY.

Herbs or shrubs; stems 4-angled; leaves simple or compound, exstipulate; flowers perfect, terminal or axillary, in spikes, racemes or panicles; calyx 4–5-parted, persistent; corolla regular or 2-lipped, 4–5-lobed; stamens 2, 4, or 5, inserted in the tube of the corolla; ovary free, 2–8-celled, 1 or 2 ovules in each cell, style simple, terminal; fruit dry and separating into several 1-seeded nutlets, or baccate.

I. VERBENA.

Annual or perennial herbs; leaves simple, opposite, serrate or pinnately lobed; flowers in terminal spikes which become much elongated in fruit; calyx tubular, 5-ribbed, 5-toothed; corolla salver-form or funnel-form, the tube often curved, bearded in the throat, limb spreading, 5-lobed, often somewhat 2-lipped; stamens 4, didynamous, rarely only 2, included; ovary 2–4-celled, 2–4-ovuled, style slender, 2-lobed; fruit 2–4 smooth or roughened, 1-seeded nutlets.

1. V. officinalis L. European Vervain. Annual; stem erect, slender, nearly or quite smooth, branching, 1–3 ft. high; leaves ovate to obovate in outline, pinnately lobed or divided, narrowed and entire toward the base, pubescent beneath; petioles margined; spikes several, very slender; flowers small, purple, bracts shorter than the calyx. June–September. In fields and waste places; introduced from Europe.

2. V. angustifolia Michx. Narrow-leaved Vervain. Perennial, rough-hairy; stem simple, or branched below, from a creeping base, 1–2 ft. high; leaves lanceolate to spatulate, obtuse and toothed at the apex, tapering to a sessile base; spike peduncled,

slender, close-flowered; bracts about the length of the calyx; corolla purple, tube slightly curved, $\frac{1}{4}$ in. long. June–September. In dry, open woods.

3. V. Canadensis (L.) Britt. Wild Verbena. Perennial; stem widely branched, diffuse, creeping at the base, pubescent, 6–15 in. long; leaves mostly 3-lobed or parted, the divisions irregularly cut and toothed, the base cuneate; petiole margined; spikes terminal, long-peduncled, at first capitate, becoming much elongated; bracts slender, shorter than the unequal, subulate calyx teeth; corolla showy, purple, $\frac{1}{2}$–$\frac{3}{4}$ in. broad, the lobes emarginate. April–July. On dry soil.

II. LIPPIA.

Perennial herbs; stems rooting at the joints; leaves simple, opposite or whorled; flowers in long-peduncled axillary and terminal spikes or heads; calyx small, 2–4-toothed; corolla tube straight or curved, the limb somewhat bilabiate, oblique; stamens 4, didynamous; ovary 2-celled, 2-ovuled, style short, stigma oblique; fruit 2 nutlets, each 1-seeded.

1. L. lanceolata Michx. Fog-fruit. Stems slender, weak, decumbent or ascending, smooth or slightly pubescent, 1–2 ft. long; leaves elliptical, acute and coarsely serrate above, the lower part of the leaf entire and narrowed to the short petiole or sessile base; peduncles slender, longer than the leaves; heads globose, becoming elongated, bracts acute; corolla pale blue, as long as the calyx. May–July. In damp places.

2. L. nodiflora (L.) Michx. Stem creeping or ascending, slightly pubescent, 6–18 in. long; leaves spatulate to obovate, coarsely toothed above, cuneate and entire below, rough; peduncles 2–4 times as long as the leaves; heads globose, becoming elongated; flowers white or purple; corolla about double the length of the calyx. May–September. In wet places.

III. CALLICARPA.

Shrubs; leaves simple, petioled, opposite or whorled, glandular-dotted; flowers in axillary cymes; calyx 4-toothed or entire; corolla funnel-form, 4-cleft, regular; stamens 4, equal, exserted; ovary 4-ovuled, style slender, stigma capitate; fruit a 1–4-seeded berry.

C. Americana L. French Mulberry. Shrubs, with stellate, glandular or scurfy pubescence, widely branched, 3–8 ft. high; leaves

ovate to oblong, acute at each end, crenate-serrate, rough above, pubescent beneath, glandular-dotted; petioles slender; cymes many-flowered, the peduncle as long as the petiole, pedicels short; calyx cup-shaped, the teeth short; corolla double the length of the calyx, blue; fruit violet-purple, very conspicuous in autumn. May–July. Common in fields and thickets.

IV. VITEX.

Shrubs; leaves palmately compound; flowers in panicled spikes; calyx short, 5-toothed; corolla cup-shaped, 5-lobed, somewhat bilabiate; stamens 4, unequal, exserted; ovary 4-celled, style slender; fruit a drupe.

V. Agnus-castus L. Chaste tree. Shrub, widely branched, 4–8 ft. high; leaflets 5–7, lanceolate, acute at each end, entire; spikes in terminal panicles, hoary-pubescent; flowers purple; corolla tube strongly curved; fruit a 1-seeded drupe or berry. April–June. Common in cultivation.

110. LABIATÆ. MINT FAMILY.

Herbs or shrubs, mostly aromatic; stems 4-angled; leaves opposite, simple, exstipulate; flowers perfect, more or less 2-lipped, axillary or terminal, often in dense whorls, sometimes solitary; calyx persistent, regular or 2-lipped, usually 5-toothed, often prominently striate; corolla bilabiate or rarely regular, limb 4–5-lobed, upper lip usually 2-lobed, the lower 3-lobed; stamens 2 or 4, inserted in the corolla tube; ovary free, 4-lobed, 4-ovuled, the slender style 2-lobed; fruit 4 nutlets, each 1-seeded.

I. TEUCRIUM.

Perennial herbs; stems erect; leaves entire or toothed; flowers in terminal spikes or axillary whorls; calyx tubular, unequally 5-toothed, 10-nerved; corolla tube short, limb 5-lobed, the 4 upper lobes short, the lower larger, oblong, concave; stamens 4, didynamous, exserted between the 2 uppermost lobes of the corolla, the lower pair longer; style 2-cleft; nutlets rugose.

T. Canadense L. Germander. Stem erect, simple or branched, tomentose, $1\frac{1}{2}$–3 ft. high; leaves lanceolate to ovate, acute at the apex, short-petioled, serrate, pubescent above, white-hoary beneath; flowers in dense hoary spikes which finally become much elongated in fruit, flower clusters usually alternate, bracted; calyx bell-shaped, pubescent, the 3 upper teeth short; corolla purplish, about $\frac{3}{4}$ in. long. June–September. On low ground.

II. TRICHOSTEMA.

Annual or perennial herbs; stems erect, branching; leaves entire; flowers in loose panicles or cymes; calyx short, the 3 lower teeth long, connate, the 2 upper short; corolla slender, the limb deeply 5-cleft; stamens 4, didynamous, long-exserted, filaments coiled; ovary deeply 4-lobed; nutlets pitted, united at the base.

T. dichotomum L. Blue Curls. Stem erect, slender, widely branched, viscid-pubescent or nearly smooth, 1–2 ft. high; leaves lanceolate to oblong, short-petioled, the upper small and bract-like; flowers in a spreading panicle, often 3 together; corolla blue to white, declined; stamens blue, very long. June–September. On dry soil.

III. SCUTELLARIA.

Perennial herbs with bitter juice; flowers in spike-like racemes or solitary in the axils; calyx 2-lipped, the lips entire, the upper with a prominent helmet-shaped protuberance on the back, deciduous, the lower persistent; corolla tube recurved-ascending, dilated at the throat, limb 2-lipped, the upper lip arched, entire or notched at the apex, middle lobe of the lower lip much the longest, spreading; stamens 4, didynamous, the upper pair shorter. anthers ciliate; ovary deeply 4-parted, style unequally 2-cleft; nutlets roughened.

S. cordifolia Muhl. Heart-leaved Skullcap. Stem slender, erect, simple or branched, pubescent, 6–18 in. high; lower leaves long-petioled, cordate or ovate, often crenate, the upper sessile, linear or elliptical, entire, pubescent; racemes mostly solitary, bracts longer than the pedicels; flowers blue and white, about 1 in. long, the lips nearly equal. June–August. On dry soil.

IV. GLECOMA.

Perennial herbs; stems creeping, widely branched, ascending at the apex; leaves petioled, orbicular to reniform; flowers in axillary clusters; calyx tubular, oblique, equally 5-toothed; corolla tube enlarged above, upper lip 2-lobed, the lower 3-lobed, the middle lobe longer, emarginate; stamens 4, didynamous, included; nutlets smooth.

G. HEDERACEA L. GROUND IVY. Stems pubescent, 6–18 in. long; leaves round-cordate, crenate, long-petioled; axillary clusters few-flowered; calyx pubescent, the teeth short; corolla blue or violet, at least twice the length of the calyx. March–May. On low ground near dwellings.

V. SALVIA.

Annual, biennial or perennial herbs, or sometimes shrubby; flowers in spikes, racemes or panicles, usually showy; calyx tubular or bell-shaped, not bearded in the throat, 2-lipped, the upper lip entire or 3-toothed, the lower 2-cleft; corolla 2-lipped, the upper lip entire or notched, the lower spreading, 3-lobed, with the middle lobe longer; stamens 2, short, anthers 2-celled, the upper cell fertile, the lower abortive; style 2-cleft; nutlets smooth.

1. S. LYRATA L. LYRE-LEAVED SALVIA. Biennial or perennial; stem erect, sparingly branched above, hirsute, 1–2 ft. high; leaves mostly basal, spreading, lyrate-pinnatifid, usually purple, stem leaves small, sessile or short-petioled; racemes many-flowered, whorls about 6-flowered; calyx teeth short on the upper lip, long and subulate on the lower; corolla blue or purple, the tube about 1 in. long, dilated upward. April–May. On dry soil.

2. S. OFFICINALIS L. GARDEN SAGE. Stem shrubby, slender, much branched below, 1 ft. high; leaves grayish-green, lance-oblong, crenate, rugose; flowers in terminal spikes, whorls several-flowered; corolla blue, upper lip strongly arched, about equaling the lower. June–August. Introduced from Europe and a common garden herb.

3. S. SPLENDENS Sell. SCARLET SAGE. Annual; stem erect, smooth, widely branched, 2–3 ft. high; leaves long-petioled, ovate, acute at the apex, narrowed or truncate at the base, crenate; flowers in slender terminal spikes; calyx about 1 in. long, corolla twice as long, both bright scarlet. June–October. Introduced from Brazil and common in cultivation.

VI. MONARDA.

Annual or perennial herbs; stem usually tall; leaves dentate or serrate; whorls capitate and axillary, dense-flowered; calyx tubular, bearded in the throat, nearly equally 5-toothed; corolla nearly equally 2-lipped, the upper lip entire or emarginate, lower lip spreading, 3-lobed; perfect stamens 2, exserted, abortive stamens 2; nutlets smooth.

1. M. FISTULOSA L. WILD BERGAMOT. Perennial, aromatic; stem erect, slender, branched, pubescent, 2–4 ft. high; leaves ovate to lanceolate, acuminate at the apex, rounded at the base, sharply serrate, petioled; whorls terminal, subtended by several conspicuous white or pale purple bracts; calyx curved, densely hairy in the throat, teeth subulate; corolla pink to purple, slender, $1\frac{1}{2}$ in. long, upper lip pubescent, entire. June–September. Dry hills and woods.

2. M. PUNCTATA L. HORSE MINT. Perennial; stem stout, pubescent, much branched, 2–3 ft. high; leaves lanceolate to oblong, acute at each end, slightly serrate, short-petioled; whorls axillary and terminal, bracts ovate to oblong, purplish; calyx slightly hairy in the throat, teeth acute; corolla yellowish, 1 in. long, the upper lip pubescent, notched, the lower spotted with brown or purple. June–October. On dry soil.

111. SOLANACEÆ. POTATO FAMILY.

Herbs or shrubs; juice often narcotic-poisonous; leaves alternate, exstipulate; flowers perfect, regular, axillary and solitary, or cymose; calyx usually 5-toothed or 5-cleft, persistent, often becoming much enlarged in fruit; corolla 5–10-lobed, rotate to salver-form or tubular, the lobes often folded and convolute in the bud; stamens inserted in the tube of the corolla and alternate with its lobes; ovary 2–5-celled, style and stigma single; fruit a 2–5-celled, many-seeded capsule or berry.

I. PHYSALIS.

Annual or perennial herbs; stems diffusely branched; leaves petioled, entire or toothed; flowers axillary, solitary, nodding; calyx 5-toothed, becoming 5-angled, much enlarged

and enclosing the fruit; corolla campanulate, plaited, 5-lobed or 5-angled, yellowish, usually with a dark brown or purple center; stamens shorter than the corolla and inserted in its tube; ovary 2-celled, style slender, stigma obtuse, 2-lobed; fruit a juicy, many-seeded berry, enclosed in the membranaceous and reticulated calyx.

1. P. PUBESCENS L. HAIRY GROUND CHERRY. Annual; stem diffusely branched, 4-angled, with one side rounded, often swollen at the nodes, tomentose or villous with viscid hairs, or sometimes nearly smooth, 1–2 ft. high; leaves long-petioled, ovate, acuminate at the apex, rounded or slightly cordate and uneven at the base, wavy-margined or entire, pubescent; calyx short in flower, with the teeth longer than the tube, becoming about 1 in. long in fruit, ovoid, retuse and sharply 5-angled at the base; corolla about $\frac{1}{3}$ in. wide, bright yellow with a brown center; filaments hairy, anthers purplish; berry yellow or greenish. June–October. Common in waste places.

2. P. ANGULATA L. WILD GROUND CHERRY. Annual; smooth throughout; stem sharply 4-angled, erect or decumbent, 1–4 ft. long; leaves ovate, acute at the apex, obtuse or truncate and uneven at the base, sharply toothed, long-petioled; calyx lobes about as long as the tube in flower, fruiting calyx ovoid, 10-angled, reticulated with purple veins; corolla small, yellow; anthers purple; berry yellow, nearly as large as the calyx. June–August.

3. P. VISCOSA L. STICKY GROUND CHERRY. Perennial from a slender rootstock; stem at first erect, becoming diffuse and decumbent, angled, viscid-pubescent, 8–20 in. long; leaves ovate and irregular in outline, acute or obtuse at the apex, mostly rounded below, angular-toothed or entire, pubescence stellate, petiole $\frac{1}{2}$–1 in. long; peduncles longer than the petioles; flowering calyx with lobes shorter than the tube, pubescent, fruiting calyx ovoid, 5-angled, truncate or slightly sunken at the base; corolla greenish-yellow, with a dark throat, about $\frac{3}{4}$ in. wide, obscurely lobed; anthers yellow; berry viscid, yellow or orange. June–October. On sandy soil.

II. SOLANUM.

Herbs or shrubs; stems often prickly, sometimes climbing; leaves alternate, often nearly or quite opposite; flowers clustered, the peduncles often opposite or above the axils; calyx spreading, 5-toothed or 5-cleft, persistent; corolla rotate, 5-lobed; stamens 5, exserted, the filaments very short, the

anthers long and connivent about the style; ovary 2-celled, style slender; fruit a many-seeded, juicy berry.

1. S. NIGRUM L. NIGHTSHADE. Annual; stem smooth, or pubescent with simple hairs, erect, diffusely branched; branches wing-angled, 1–3 ft. high; leaves ovate, irregularly toothed or entire, somewhat inequilateral, petioled; flowers in lateral, peduncled umbels, small, white, drooping; calyx lobes obtuse; corolla $\frac{1}{3}$–$\frac{1}{2}$ in. wide; filaments pubescent; berries globose, smooth, black when ripe. June–September. Common in cultivated fields and waste places; poisonous.

2. S. CAROLINENSE L. HORSE NETTLE. Perennial; stem erect, branched, pubescent with stellate hairs, armed with straight, yellow prickles, 1–3 ft. high; leaves ovate-oblong, deeply toothed or lobed, acute at the apex, abruptly contracted to the short petiole, prickly on the veins; racemes lateral, few-flowered; pedicels recurved in fruit; calyx lobes acuminate; corolla deeply angular-lobed, blue or white; berry globose, smooth, yellow. May–September. A common weed.

3. S. ROSTRATUM Dunal. SAND BUR. Annual; the whole plant beset with yellow prickles; stem erect, diffusely branched, 1–2 ft. high; leaves broadly oval or ovate in outline, deeply pinnately lobed or parted, petioled, pubescent with stellate hairs; racemes few-flowered; pedicels erect in fruit; calyx very prickly, becoming enlarged and enclosing the fruit; corolla bright yellow, 5-angled, about 1 in. broad. May–September. Introduced from the west, and becoming a troublesome weed in some places.

4. S. TUBEROSUM L. IRISH POTATO. Annual; stem diffusely branched, pubescent, underground branches numerous and tuber-bearing; leaves irregularly pinnatifid and divided; flowers in cymose clusters, white or purple, with prominent yellow anthers; pedicels jointed; corolla 5-angled, $\frac{3}{4}$–1 in. broad; fruit a globose, greenish-yellow, many-seeded berry, about $\frac{1}{2}$ in. in diameter. March–October. Cultivated.

III. LYCOPERSICON.

Annual; stem diffusely branched; leaves pinnately divided; flowers in raceme-like clusters on peduncles opposite the leaves; calyx 5–many-parted, persistent; corolla rotate, 5–6-parted; stamens 5–6, inserted in the short tube of the corolla, filaments short, anthers elongated, connivent; ovary 2–several-celled, style and stigma simple; fruit a many-seeded berry.

L. Lycopersicon (L.) Karst. Tomato. Stem diffusely branched and becoming decumbent, furrowed and angled below, viscid-pubescent, 3–5 ft. long; leaves irregularly lobed and pinnatifid, petioled; calyx lobes linear, about as long as the yellow corolla; fruit (in the wild state) globose or ovoid, red or yellow, $\frac{1}{4}$–$\frac{1}{2}$ in. in diameter, but greatly enlarged in cultivation. May–September. Common in cultivation and often spontaneous.

IV. LYCIUM.

Shrubs or woody vines, often spiny; leaves entire, alternate, often fascicled; flowers solitary or clustered, terminal or axillary; calyx persistent, 4–5-lobed or toothed, not enlarged in fruit; corolla funnel-form or campanulate, the limb 4–5-lobed, the lobes obtuse; stamens 4–5, exserted; ovary 2-celled, style single, stigma obtuse; fruit a many-seeded berry.

L. vulgare (Ait.) Dunal. Matrimony Vine. Stem slender, branching, twining or trailing, 6–15 ft. long; branches angled, spiny; leaves elliptical, smooth, entire, sessile or short-petioled; flowers solitary or few in the axils; peduncles long and slender; corolla spreading, greenish-purple, $\frac{1}{3}$–$\frac{1}{2}$ in. wide; berry oval, orange-red. April–July. Introduced from Africa, and often planted for covering trellises.

V. DATURA.

Annual or perennial, strong-scented herbs; stems tall and branching; leaves petioled, entire or lobed; flowers large, solitary in the forks of the branches; calyx tubular, 5-toothed or lobed, the upper part deciduous, the lower persistent; corolla funnel-form, 5-angled, plaited, convolute in the bud; stamens 5, inserted in the corolla tube; ovary 2-celled or imperfectly 4-celled, style filiform, stigma 2-lobed; fruit a spiny, 4-valved, many-seeded capsule.

1. D. Stramonium L. Jimson-weed. Annual; stem smooth, green, stout, forking above, 1–4 ft. high; leaves ovate to oblong-ovate, acute at the apex, narrowed at the base, sinuate-toothed, petioled; calyx 5-angled; corolla white, about 4 in. long; capsule ovoid, erect, 2 in. long. May–October. A common weed; poisonous.

2. D. Tatula L. Purple Jimson-weed. Annual; stem erect, rather slender, slightly pubescent, purplish, 2–5 ft. high; leaves

petioled, sinuate-toothed, often truncate or cordate at the base; flowers purplish; very similar to the preceding species. May–October. Common and poisonous.

3. D. METEL L. THORN-APPLE. Annual; stem erect, stout, branching, glandular-pubescent, 3–6 ft. high; leaves ovate, acute at the apex, rounded or truncate at the base, entire or slightly toothed; calyx not angled, about 3 in. long; corolla white, 10-toothed, 6–7 in. long; capsule globose, nodding. June–September. Introduced from South America.

112. SCROPHULARIACEÆ. FIGWORT FAMILY.

Herbs, shrubs or trees; leaves simple, opposite or alternate, exstipulate; flowers perfect, mostly complete, irregular; calyx 4–5-toothed, persistent; corolla tubular, withering-persistent, often bilabiate, the upper lip 2-lobed or entire, the lower 3-lobed; stamens 2–4, rarely 5, inserted on the tube of the corolla and alternate with its lobes; ovary free, 2-celled, with axial placentæ, style slender, curved, stigma thick, 2-lobed; fruit a 2-celled, many-seeded capsule.

Corolla rotate . . . . I. Verbascum.
Corolla tubular, saccate at the base . . . III. Antirrhinum.
Corolla tubular, spurred at the base . . . II. Linaria.
Corolla tubular or campanulate, not spurred or saccate.
  Stamens 2 . . . . VIII. Leptandra.
  Stamens 4.
    Corolla bilabiate.
      Sterile filament as long as the fertile stamens V. Pentstemon.
      Sterile filament shorter than the fertile stamens IV. Chelone.
      Sterile filament wanting . . . . VII. Mimulus.
    Corolla irregular, but not bilabiate.
      Trees . . . . VI. Paulownia.
      Herbs.
        Flowers pink, purple or white . . X. Gerardia.
        Flowers yellow . . . . . IX. Dasystoma.

I. VERBASCUM.

Biennial; stem slender, erect; leaves alternate; flowers in spikes, racemes or panicles; calyx deeply 5-cleft; corolla rotate, 5-lobed, the lobes nearly equal; stamens 5, unequal, declined, some or all of the filaments bearded; style flattened at the apex; fruit a globose capsule, seeds roughened.

V. Blattaria L. Moth Mullein. Stem erect, slender, simple or sparingly branched, smooth below, pubescent above, 2–4 ft. high; leaves oblong to lanceolate, acute at the apex, obtuse or truncate at the base, dentate to pinnately lobed, the lower petioled, the upper sessile and clasping; raceme long and loose, glandular-pubescent, pedicels bracted; corolla white or yellow, marked with brown on the back, about 1 in. wide; filaments all bearded with purple hairs; capsule longer than the calyx. April–July. Common in fields and waste places; naturalized from Europe.

II. LINARIA.

Annual, biennial or perennial; leaves mostly alternate on the flowering stems, often opposite or whorled at the base and on sterile stems, entire, dentate or lobed; flowers in bracted spikes or racemes; calyx 5-parted; corolla spurred at the base, upper lip erect, emarginate or 2-lobed, the lower lip spreading, 3-lobed, the throat nearly closed by a prominent palate; stamens 4, didynamous, included; fruit a globose capsule opening at the base.

L. Canadensis (L.) Dumont. Toad-flax. Biennial; flowering stems erect, slender, rarely branched, smooth, 1–2 ft. high, sterile stems prostrate, with opposite or whorled leaves, 2–6 in. long; leaves linear, entire, sessile; racemes erect, slender; pedicels erect, as long as the calyx; corolla small, blue and white, the spur filiform, curved, longer than the pedicels; capsule 2-valved, the valves 3-toothed. April–May. On dry or cultivated ground.

III. ANTIRRHINUM.

Annual or perennial herbs; leaves alternate or sometimes opposite on sterile shoots; flowers axillary or in terminal racemes; calyx 5-parted; corolla saccate at the base, the

upper lip erect, 2-lobed, the lower spreading, 3-lobed, the prominent palate nearly closing the throat; stamens 4, didynamous, included; style filiform, its base often persistent; capsule globose to oblong, seeds smooth or roughened.

A. MAJUS L. SNAPDRAGON. Perennial; stem erect, smooth below, glandular-pubescent above, 1–2 ft. high; leaves linear to oblong-lanceolate, entire, smooth, sometimes fleshy, sessile or short-petioled; flowers in a terminal raceme; pedicels short, stout, erect in fruit; corolla $1\frac{1}{2}$–2 in. long, of many colors; capsule oblique, the persistent base of the style bent forward. May–September. Common in gardens and often escaped.

IV. CHELONE.

Perennial herbs; stem smooth; leaves opposite, serrate, petioled; flowers large, in dense, bracted spikes; calyx 5-parted; corolla white or purple, inflated-tubular, the upper lip concave, emarginate, the lower spreading, woolly within, the middle lobe often shorter; stamens 5, one of them small and sterile, the anthers didynamous, filaments and anthers woolly; seeds broadly winged.

C. GLABRA L. SNAKE-HEAD. Stem erect, simple or branched, 4-sided, 2–3 ft. high; leaves lanceolate, acuminate, short-petioled, serrate, sometimes pubescent beneath; spike terminal, short, simple or branched, nearly sessile; bracts ovate; corolla white or pink, 1–$1\frac{1}{2}$ in. long. June–September. Along streams.

V. PENTSTEMON.

Perennial; stem erect, rarely branched; leaves opposite, or the upper sometimes alternate; flowers white or purple, in terminal cymes or panicles; calyx 5-parted; corolla tube enlarged or inflated above, upper lip concave, emarginate or 2-lobed, the lower 3-lobed; stamens 5, included, declined at the base, 4 of the stamens anther-bearing and didynamous, the other sterile and usually bearded; style slender; capsule 2-valved, seeds wingless.

1. P. HIRSUTUS (L.) Willd. HAIRY BEARD-TONGUE. Stem erect, slender, pubescent, 18–24 in. high; lower leaves ovate to ovate-lanceolate, long-petioled, the middle leaves oblanceolate, tapering to

the base, the upper leaves lanceolate, sessile and clasping, all dentate or serrate, smooth or slightly pubescent; cymes loose, few-flowered, glandular-pubescent; pedicels short; corolla tube about 1 in. long, dilated above, 2-grooved below, the throat with a densely bearded palate; sterile filament densely bearded above. May–July. In open, dry woods.

2. P. CANESCENS Britt. GRAY BEARD-TONGUE. Stem erect, stout, pubescent, often several from the same root, 2–3 ft. high; lower leaves oval, the long petiole margined, upper leaves ovate-lanceolate, sessile, all denticulate, slightly pubescent; cymes loose, pedicels short; corolla tube white to purple, about 1 in. long, throat smooth or slightly bearded; sterile stamen slightly bearded near the apex. May–July. In dry, open woods.

VI. PAULOWNIA.

A tree having much the appearance of Catalpa; leaves opposite, long-petioled, entire or 3-lobed; flowers purple or violet, in large terminal panicles; calyx short, 5-cleft; corolla with a long tube which is spreading above. lobes spreading, nearly equal; stamens 4, included, didynamous; style slender; fruit a dehiscent, ovoid capsule, seeds winged and striate.

P. TOMENTOSA (Thunb.) Britt. PAULOWNIA. A tree with gray bark and a rounded top; leaves ovate to 3-lobed, pubescent, 6–10 in. wide; flowers 2–3 in. long, in spreading panicles 2–3 ft. long; pedicels stout, tomentose; capsule coriaceous, dehiscent. April–May. Introduced from Japan. The panicles with the large flower buds are developed from September to November and are conspicuous during the winter months.

VII. MIMULUS.

Perennial; stem erect or decumbent; leaves opposite; flowers axillary and solitary, mostly yellow or purple; calyx tubular, 5-angled, 5-toothed; corolla tube with 2 ridges within on the lower side, upper lip erect or reflexed, lower lip spreading; stamens 4, didynamous; style slender, 2-lobed; capsule 2-valved, many-seeded.

1. M. RINGENS L. SQUARE-STEMMED MONKEY FLOWER. Stem 4-angled, erect, branched, smooth, 1–2 ft. high; leaves lanceolate to

oblong, serrate, sessile or clasping at the base; peduncles slender, longer than the flowers; corolla violet, about 1 in. long, lower lip puberulent within. June–September. Along streams and in wet places.

2. M. ALATUS Soland. SHARP-WINGED MONKEY FLOWER. Stem square, wing-angled, erect, smooth, 1–2 ft. high; leaves ovate to oblong, acuminate, serrate, short-petioled; peduncles shorter than the flowers; calyx teeth short; corolla violet, about 1 in. long. June–August. In swamps and wet places.

VIII. LEPTANDRA.

Perennial herbs; stems tall, stout; leaves opposite or verticillate; flowers in dense terminal or axillary peduncled spikes; calyx small, 4-parted; corolla tubular, 4-lobed, the lobes nearly equal; stamens 2, long-exserted; style long and slender, stigma capitate; capsule ovoid, 4-valved, seeds reticulated.

L. VIRGINICA (L.) Nutt. CULVER'S ROOT. Stem erect, smooth or slightly pubescent, simple or with few branches above, 2–5 ft. high; leaves 3–7 in a whorl, lanceolate to oblong, acuminate at the apex, sharply serrate, smooth or sometimes pubescent beneath, short-petioled; spikes solitary or several; flowers bracted, small, white or purplish; stamens nearly twice the length of the corolla; capsule twice the length of the calyx. June–August. In meadows and open woods.

IX. DASYSTOMA.

Coarse annual or perennial herbs; leaves opposite; flowers yellow, in terminal leafy racemes or panicles; calyx bell-shaped, 5-lobed, the lobes often toothed; corolla tubular-bell-shaped, woolly within, the limb spreading, 5-lobed, slightly irregular; stamens 4, included, didynamous, woolly, anthers awned at the base; style filiform, thickened at the apex; fruit an ovate, 2-valved capsule.

1. D. FLAVA (L.) Wood. DOWNY FALSE FOXGLOVE. Perennial; stem erect, downy, mostly simple, 2–4 ft. high; leaves lanceolate to oblong, the lower pinnately lobed or pinnatifid, short-petioled, the upper nearly entire and sessile; pedicels stout; calyx lobes entire; corolla $1\frac{1}{2}$ in. long, smooth; capsule pubescent, twice the length of the calyx. June–September. In dry woods.

2. D. VIRGINICA (L.) Britt. SMOOTH FALSE FOXGLOVE. Perennial; stem erect, branched, smooth and glaucous, 3–6 ft. high; leaves petioled, the lower twice pinnatifid, the others incised and cut, or the upper lanceolate and entire; calyx shorter than the pedicels, the lobes as long as the tube; corolla about 2 in. long, the tube rather slender; capsule oval, smooth, twice the length of the calyx. June–September. In rich woods.

X. GERARDIA.

Annual or perennial herbs; mostly blackening in drying; leaves opposite or rarely alternate, narrow and entire; flowers usually showy, in the axils of the upper leaves; calyx campanulate, 5-toothed; corolla funnel-form or tubular-bell-shaped, 5-lobed, the throat oblique; stamens 4, included, didynamous, the longer filaments and anthers woolly; style slender, flattened and dilated above; capsule globose; seeds angled. Mostly flowering late in the season.

1. G. LINIFOLIA Nutt. FLAX-LEAVED GERARDIA. Perennial; stem very slender, erect, branched, smooth, 2–3 ft. high; leaves erect, narrowly linear, the upper bract-like; peduncles about as long as the leaves; calyx truncate, with minute teeth; corolla purple, about 1 in. long, the lobes nearly equal, rounded, fringed; filaments villous; capsule globose, longer than the calyx. August–September. Dry pine barrens.

2. G. PURPUREA L. PURPLE GERARDIA. Annual; stem erect, slender, smooth or slightly rough, branched above, 1–3 ft. high; leaves linear, spreading, rough; pedicels stout, as long as the calyx; corolla purple to white, about 1 in. long and wide, the lobes minutely fringed, pubescent within; capsule longer than the calyx. August–September. On low ground.

113. LENTIBULACEÆ. BLADDERWORT FAMILY.

Annual or perennial herbs growing in water or in muddy places; leaves in a rosulate basal tuft and entire, or floating and dissected; scapes erect; flowers perfect, irregular, solitary or racemed; pedicels bracted; calyx 2-lipped, 2–5-lobed or parted; corolla 2-lipped, spurred at the base, upper lip erect, entire or 2-lobed, lower lip spreading or reflexed, 3-lobed,

throat with a prominent palate; stamens 2, included; ovary free, 1-celled, ovoid, style short, stigma 2-lobed; fruit a globose, many-seeded capsule, seeds roughened.

I. UTRICULARIA.

Annual or perennial; floating in still water by means of numerous small air bladders attached to the finely dissected leaves, or growing in wet soil with entire leaves and few or no air bladders; scapes 1–many-flowered; calyx lips entire; corolla with the upper lip entire, the lower larger and 3-lobed, the throat usually bearded within and nearly closed by the palate.

1. U. CORNUTA Michx. HORNED BLADDERWORT. Acaulescent; leaves linear and entire or none; air bladders few or none; scape erect, stout, 2–5-flowered, 8–12 in. high; flowers yellow, fragrant, $\frac{3}{4}$ in. wide; pedicel as long as the calyx; the lips of the corolla obovate, unequal, the lower longer, abruptly pointed, the sides reflexed, as long as the horn-shaped, curved spur, throat bearded; seeds minutely pitted. May–August. In swamps and muddy places.

2. U. SUBULATA L. SMALL BLADDERWORT. Scape filiform, 2–6 in. high; leaves few and setaceous or none; air bladders few or none; racemes zigzag, 1–6-flowered; pedicels much longer than the calyx; corolla yellow, $\frac{1}{4}$ in. wide, the lower lip 3-lobed, longer than the appressed, conical, green-pointed spur. February–May. Wet, sandy soil.

3. U. INFLATA Walt. SWOLLEN BLADDERWORT. Perennial; stem very slender, floating; lower leaves scattered, finely dissected, upper leaves whorled, finely dissected; the petioles dilated upward and inflated, air bladders very numerous; scape stout, 6–12 in. high, 3–10-flowered; corolla yellow, about $\frac{3}{4}$ in. wide, upper lip ovate, slightly lobed, lower lip 3-lobed, twice the length of the curved, emarginate spur; fruit nodding. March–June. In ponds and still water.

II. PINGUICULA.

Perennial, acaulescent herbs; leaves in a rosulate, basal cluster, entire, margins involute, surface covered with a sticky secretion; scapes naked, circinate, 1-flowered; calyx 2-lipped, the upper lip 2-lobed, the lower 3-lobed; corolla 2-lipped, the

upper lip 2-lobed, the lower 3-lobed and saccate or spurred at the base, palate hairy; capsule 2- or 4-valved.

1. P. LUTEA Walt. YELLOW MARSH VIOLET. Leaves viscid-pubescent, yellowish-green, oblong-obovate, acute, coarsely cellular and very watery; scape 6–12 in. high; flower 1–1½ in. wide, bright yellow, nodding; spur slender, half the length of the rounded lobes of the corolla. February–April. Marshes in pine barrens.

2. P. ELATIOR Michx. PURPLE MARSH VIOLET. Leaves ovate to spatulate, acute, coarsely cellular and watery, clammy-pubescent; scape villous near the base, slender, 8–12 in. high; calyx glandular; corolla purple or blue, 1 in. wide, the rounded lobes very unequal, the spur obtuse. March–April. Wet, sandy soil.

114. BIGNONIACEÆ. BIGNONIA FAMILY.

Trees, shrubs or woody vines; leaves simple or compound, opposite or alternate, exstipulate; flowers showy, in terminal or axillary clusters, perfect, somewhat irregular; calyx 2-lipped and 5-lobed, or truncate and entire; corolla funnel-form or tubular, 2-lipped, 5-lobed; stamens 2 or 4 and didynamous, inserted in the tube of the corolla; ovary 2-celled, many-ovuled, style slender, stigma 2-lobed; fruit a 2-valved, 2- or 4-celled, many-seeded capsule.

I. BIGNONIA.

Woody vines; leaves opposite, compound, usually tendril-bearing; flowers large, in axillary clusters; calyx cup-shaped, truncate or undulate-toothed; corolla spreading-tubular, somewhat 2-lipped, the lobes rounded; stamens 4, didynamous; capsule linear, flattened parallel with the partition, the 2 valves separating from the partition at maturity; seeds flat, broadly winged.

B. CRUCIGERA L. CROSS-VINE. Stem climbing high, a transverse section of the older stems showing a conspicuous cross formed by the 4 medullary rays; branches glabrous; leaves evergreen, petioled; leaflets 2, ovate, acuminate with a blunt apex, cordate at the base, entire, stalked, upper leaflets transformed into branching tendrils; flowers numerous, short-peduncled; corolla 2 in. long,

reddish-brown without, yellow within; capsule 6 in. long, flat, the valves with a prominent central nerve; seeds broadly winged on the sides, short-winged on the ends. March–April. Common in woods.

II. TECOMA.

Woody vines, climbing by aërial rootlets; leaves compound, odd-pinnate; flowers large, in terminal clusters; calyx bell-shaped, unequally 5-toothed; corolla funnel-form, enlarged above the calyx, 5-lobed, slightly 2-lipped; stamens 4, didynamous; capsule slender-fusiform, slightly compressed contrary to the partition, 2-valved, dehiscent; seeds winged.

T. RADICANS (L.) DC. TRUMPET FLOWER. Stems climbing high by numerous rootlets, bark shreddy; leaves deciduous, petioled; leaflets 9–11, ovate to ovate-lanceolate, serrate, short-stalked, smooth or slightly pubescent; flowers in short, terminal racemes or corymbs; calyx tubular, $\frac{3}{4}$ in. long; corolla 2–3 in. long, scarlet without, yellow within, the lobes spreading; capsule 5–6 in. long, curved, often persistent through the winter; seeds broadly winged. May–June. On borders of fields and in woods.

III. CATALPA.

Small trees; leaves opposite, simple, petioled, deciduous; flowers large and showy, in terminal panicles; calyx irregularly 2-lipped; corolla tubular-bell-shaped, oblique, 5-lobed, 2-lipped; fertile stamens 2, sterile stamens 3, short; fruit a linear, 2-valved, many-seeded capsule; seeds winged.

C. CATALPA (L.) Karst. CATALPA. A small tree with thin, rough, gray bark and light, soft, but exceedingly durable wood; leaves long-petioled, cordate, entire or palmately 3-lobed, acuminate at the apex, palmately veined, pubescent; branches of the panicle in 3's; flowers large, 1–1½ in. long, white, variegated with yellow and purple; corolla lobes undulate or crisped; capsule very slender, 1 ft. or more in length, pendulous; seeds with long, fimbriate wings. April–June. On margins of rivers and swamps.

115. MARTYNIACEÆ. UNICORN-PLANT FAMILY.

Herbs; leaves entire, petioled, the lower opposite, the upper alternate; flowers perfect, irregular, in terminal racemes;

calyx 4–5-cleft or parted, often split to the base on one side; corolla spreading, tubular, oblique, 2-lipped, 5-lobed, the lobes nearly equal and spreading; fertile stamens 2 or 4; ovary 1-celled, but often becoming 2- or 4-celled by the intrusion of the parietal placentæ, style slender, stigma 2-lobed; fruit a 2-valved, woody capsule beaked by 2 long and recurved horns, seeds numerous.

MARTYNIA.

Characters of the family.

M. LOUISIANA Mill. UNICORN PLANT. Annual herbs, densely viscid-pubescent; stem stout, diffusely branched, becoming decumbent, 2–4 ft. long; leaves round-cordate, undulate or entire; petiole long and stout; racemes short, few-flowered; calyx 5-cleft, with 2 or 3 bracts at the base; corolla $1\frac{1}{2}$–2 in. long, whitish, tinged with yellow and purple, tube somewhat curved; capsule 5–6 in. long, crested on one side, shorter than the divergent, recurved horns. June–August. In waste places.

116. ACANTHACEÆ. ACANTHUS FAMILY.

Herbs; stems usually 4-sided, often swollen between the joints; leaves simple, opposite, exstipulate; flowers usually axillary, perfect, often irregular, bracted; calyx 4–5-parted, persistent; corolla 5-lobed, often 2-lipped; fertile stamens 2 or 4, inserted in the tube of the corolla; ovary free, 2-celled, few- or many-seeded, style filiform, stigma entire or 2-lobed; fruit a 2-celled, few–many-seeded capsule which is dehiscent by 2 elastic valves, seeds globose or flattened, not winged.

I. RUELLIA.

Perennial herbs; stems swollen at the joints and often between them, somewhat 4-angled; leaves sessile or short-petioled, mostly entire; flowers axillary, solitary or clustered, showy, white, blue or purple; calyx 2-bracted, 5-parted, the

divisions linear and subulate; corolla tube slender, often much elongated, the limb spreading, nearly equally 5-lobed; stamens 4, didynamous, included or slightly exserted; style slender; capsule slender, narrowed below, 4–12-seeded.

1. R. STREPENS L. SMOOTH RUELLIA. Stem erect, slender, usually simple, smooth or hairy, 1–3 ft. high; leaves ovate to oblong, acute at the apex, narrowed below into a short petiole; flowers solitary or in small clusters, sessile or short-peduncled; calyx lobes shorter than the tube of the corolla, pubescent or ciliate; corolla blue, the tube $1\frac{1}{2}$–2 in. long, the limb 1–$1\frac{1}{2}$ in. wide; capsule usually longer than the calyx, smooth, 8–12-seeded; the later flowers often without a corolla. May–September. On rich, dry soil.

2. R. CILIOSA Pursh. HAIRY RUELLIA. Stem erect, rather stout, often few-branched above, hirsute with white hairs, 4–30 in. high; leaves oblong to ovate, acute or obtuse at the apex, narrowed and mostly sessile at the base, ciliate; flowers pale blue, solitary or 2-3 together; calyx lobes setaceous, half the length of the corolla tube; tube of the corolla 2 in. long; capsule shorter than the calyx, smooth, 8–12-seeded; a very variable species, the flowers often without a corolla. June–September. In dry woods and fields.

II. DIANTHERA.

Perennial herbs; stem smooth; leaves opposite, entire or dentate; flowers axillary, solitary or clustered, irregular; calyx 5-parted; corolla bilabiate, upper lip erect, concave, entire or emarginate, the lower prominently veined, spreading, 3-lobed; stamens 2, inserted in the throat of the corolla; ovary 2-celled, 4-ovuled, style simple, acute; capsule flattened, narrowed below into a stipe.

1. D. AMERICANA L. WATER WILLOW. Stem erect, slender, 2–3 ft. high; leaves lanceolate to linear lanceolate, acuminate at the apex, narrowed below to the sessile or short-petioled base; flowers bracted, in short spikes, on peduncles as long as the leaves; corolla pale blue or purple, the tube as long as the lips, lower lip rugose; capsule about the length of the calyx. May–August. In water.

2. D. OVATA Walt. LOOSE-FLOWERED WATER WILLOW. Stems erect or ascending from a creeping base, slender, simple, 4–12 in. high; leaves ovate to lanceolate, sessile or short-petioled; spikes few-flowered, on peduncles shorter than the leaves; calyx lobes subulate; corolla less than $\frac{1}{2}$ in. long, pale purple, the lower lip with darker veins; capsule longer than the calyx. May–August. On muddy banks.

117. PLANTAGINACEÆ. PLANTAIN FAMILY.

Acaulescent herbs from fibrous roots; leaves basal, prominently veined; scape erect, bearing a terminal spike or head of small, perfect, polygamous or diœcious flowers; calyx of 4 scarious-margined, persistent sepals; corolla rotate or salverform, the tube short, the limb 4-parted, scarious; stamens 2 or 4, included or exserted, inserted in the tube of the corolla and alternate with its lobes, filaments slender, anthers versatile; ovary free, 2- or 4-celled, style slender; fruit a 2-celled, few- or many-seeded capsule, dehiscence circumscissile.

PLANTAGO.

Characters of the family.

1. P. MAJOR L. PLANTAIN. Perennial, from a very short rootstock; leaves ovate to oval, strongly 5–9-ribbed, acute or obtuse at the apex, rounded at the base into a long, concave petiole, entire or toothed, smooth or slightly pubescent; scape taller than the leaves, pubescent, spike densely flowered; bracts short, ovate; flowers perfect; stamens 4, exserted; capsule ovoid, about twice the length of the calyx. April–August. Common in dooryards.

2. P. LANCEOLATA L. RIBGRASS. Biennial or perennial; villous or nearly smooth; leaves numerous, lanceolate to elliptical, acute, long-petioled, strongly 3–5-ribbed, entire or toothed; scapes much longer than the leaves, striate-angled, 1–2 ft. high, spike short and dense; bracts and sepals ovate; corolla glabrous; capsule longer than the calyx, 2-seeded. March–October. Introduced; common in meadows.

3. P. ARISTATA Michx. LARGE-BRACTED PLANTAIN. Annual; leaves broadly linear, entire or sparingly denticulate, narrowed below into a margined petiole, smooth or silky-pubescent; scape longer than the leaves, 6–10 in. high, spike dense; bracts linear, ½–1 in. long; stamens 4; capsule 2-seeded, longer than the calyx. April–September. Common on dry soil.

4. P. HETEROPHYLLA Nutt. MANY-SEEDED PLANTAIN. Annual; leaves linear, fleshy, entire or with a few spreading teeth, smooth or slightly pubescent; scapes slender, 3–6 in. high, spike very slender, many-flowered, the lower flowers often scattered; bracts ovate, longer than the sepals; stamens 2; capsule twice the length of the calyx, many-seeded. March–May. Common in cultivated ground.

118. **RUBIACEÆ.** MADDER FAMILY.

Herbs, shrubs or trees; leaves simple, opposite or whorled; flowers perfect, regular, axillary or terminal; calyx tube adherent to the ovary, the limb 4–6-toothed or wanting; corolla rotate to funnel-form, 4–6-lobed, inserted in the throat of the calyx; stamens inserted in the throat of the corolla, as many as its lobes and alternate with them; ovary 1–several-celled, style single; fruit a capsule, drupe or berry.

I. **HOUSTONIA.**

Annual, biennial or perennial herbs; stems erect or diffuse; leaves entire, stipules often only a line connecting the bases of opposite leaves; flowers small, solitary or clustered; calyx 4-toothed, persistent; corolla rotate to funnel-form, 4-lobed; stamens 4; ovary 2-celled, style slender, stigmas 2; fruit a 2-celled, few–many-seeded capsule, dehiscent at the apex, which is free from the calyx.

1. H. CŒRULEA L. BLUETS. Perennial, from very slender rootstocks; stems tufted, erect, smooth, forking, 3–6 in. high; leaves sessile, often ciliate, the lower spatulate, the upper lanceolate; flowers solitary, on slender, axillary peduncles; calyx small; corolla salver-form, blue or white, yellow in the throat: flowers of two forms, the stamens exserted and the style short in one form, while in the other the stamens are short and the style exserted; capsule laterally compressed, 2-lobed, shorter than the calyx. February–April. Common on open ground.

2. H. MINOR (Michx.) Britt. SMALL BLUETS. Annual; stem erect, branched at the base, forking above, smooth, 2–4 in. high; lower leaves oval to ovate, petioled, the upper narrower and sessile; flowers solitary, on slender, axillary peduncles, blue or white; calyx small; lobes of the corolla about as long as the tube; stamens and style exserted or included; capsule compressed, as long as the calyx. February–April. Common on dry, open ground.

3. H. PURPUREA L. LARGE BLUETS. Perennial; stem stout, erect, simple or branched, smooth or pubescent, 4-angled, 6–12 in. high; leaves ovate to ovate-lanceolate, sessile or short-petioled, 3–5-nerved, often ciliate on the margins; flowers in terminal cymes, purple to nearly white; corolla funnel-form, the tube longer than

the limb, hairy within; stamens and style exserted or included; capsule compressed-globose, much shorter than the calyx. May–July. In dry, open woods.

4. H. LONGIFOLIA Gaertn. LONG-LEAVED BLUETS. Perennial; stem erect, branched, smooth, 4-angled, 8–12 in. high; leaves sessile, the lower oblanceolate or spatulate, the upper linear, 1-nerved; corymbs terminal, few-flowered; corolla light purple to white, the lobes much shorter than the tube; capsule compressed-globose, nearly as long as the calyx. May–July. In dry, open woods.

II. CEPHALANTHUS.

Shrubs; leaves opposite, entire, short-petioled, stipulate; flowers white, in axillary, long-peduncled heads; calyx obconic, 4-lobed; corolla tubular, 4-lobed; stamens 4, filaments short; ovary 2-celled, 2-ovuled, style slender, exserted, stigma capitate; fruit dry, obconical.

C. OCCIDENTALIS L. BUTTON-BUSH. A branching shrub, 5–10 ft. high, young branches pubescent; leaves ovate-oblong, acute at each end, smooth or pubescent; stipules triangular; peduncles nearly as long as the leaves; heads globose, about 1 in. in diameter; style twice the length of the corolla; ovary much shorter than the calyx. June–August. Common on wet ground.

III. MITCHELLA.

Perennial; stem very slender, woody, creeping; leaves entire, petioled, stipulate, evergreen; flowers in pairs on axillary or terminal peduncles; calyx 4-lobed; corolla funnelform, 4-lobed, hairy within; stamens 4, alternate with the lobes of the corolla; ovary 4-celled, 4-ovuled, stigmas 4; stamens included and style exserted, or stamens exserted and style included; fruit 2 united, 4-seeded drupes or berries.

M. REPENS L. TWIN-BERRY. Stem rooting at the joints, smooth, 1–2 ft. long; leaves broadly ovate to cordate, dark green, shining above; stipules minute; peduncles shorter than the leaves; flowers white, the buds tinged with pink, ½ in. long; fruit bright red, "two-eyed" above by the remains of the calyces, persistent through the winter, edible. March–May. In rich, damp woods.

IV. DIODIA.

Annual or perennial herbs; stems diffuse; leaves opposite, sessile, the sheathing stipules bristly fringed; flowers axillary, solitary or in small clusters; calyx 2–4-lobed, persistent; corolla funnel-form to salver-form, usually 4-lobed; stamens 4, exserted; ovary 2-celled, style slender, exserted, stigmas 2; fruit dry and indehiscent or somewhat fleshy, 2-celled, 2-seeded, seeds bony.

1. D. TERES Walt. POVERTY-WEED. Annual; stem erect or diffuse, much branched from the base, bristly or hairy, somewhat 4-angled, 6–18 in. high; leaves linear to linear-lanceolate, acute, sessile, rough, the margins revolute; flowers purplish; corolla funnel-form, $\frac{1}{4}$–$\frac{1}{3}$ in. long; fruit obovoid, crowned with the persistent calyx lobes. June–September. On dry, barren soil.

2. D. VIRGINIANA L. LARGE POVERTY-WEED. Perennial; stem widely branched, smooth or hispid, 4-angled, diffuse and often prostrate, 1–4 ft. long; leaves lanceolate, acute, sessile, somewhat fleshy; flowers white or purplish, solitary or few together; corolla tube very slender, $\frac{1}{3}$ in. long, the lobes spreading, hairy within; fruit ovoid, strongly ribbed, dry or slightly fleshy, crowned with the 2–4-persistent calyx teeth. June–September. On wet, sandy soil.

V. GALIUM.

Annual or perennial herbs; stems slender, 4-angled; leaves verticillate; flowers small, in axillary or terminal cymes or panicles, perfect or rarely diœcious; calyx tube short, the teeth minute or wanting; corolla rotate, 3–4-lobed; stamens 3–4, short; ovary 2-celled, styles 2, short, united below; fruit 2 united, indehiscent, 1-seeded carpels, sometimes fleshy.

1. G. APARINE L. GOOSEGRASS. Annual; stem weak, decumbent, sharply 4-angled and retrorsely hispid, widely branched, 2–4 ft. long; leaves 6–8 in a whorl, oblanceolate, hispid on the margins and mid-rib; peduncles axillary, longer than the leaves, 1–3-flowered; flowers white; fruiting pedicels erect; fruit dry, covered with hooked bristles. April–September. In waste places.

2. G. PILOSUM Ait. HAIRY BEDSTRAW. Stem rigid, erect or ascending, hairy or roughened on the angles, branched, 1–3 ft. long; leaves 4 in a whorl, small, oval, acute, rough-hairy, and punctate-dotted; peduncles several times forked, ultimate branches 1–3-flow-

ered: flowers greenish-purple; pedicels erect; fruit dry, densely bristly. May–September. On dry soil.

3. G. CIRCÆZANS Michx. WILD LICORICE. Perennial; stems several, erect, smooth or pubescent, 12–18 in. high; leaves 4 in a whorl, oval to ovate, obtuse at the apex, strongly 3-nerved, pubescent; cymes long-peduncled, repeatedly branched; flowers nearly sessile, greenish-purple; pedicels at length recurved; fruit with hooked bristles. May–August. In dry, open woods.

4. G. HISPIDULUM Michx. BEDSTRAW. Perennial, from yellow roots; stems diffusely branched, smooth or slightly roughened, pubescent at the joints, erect or decumbent, 1–2 ft. long; leaves 4 in a whorl, narrowly oval, acute, rough on the margins and mid-vein; peduncles 1–3-flowered; flowers white; pedicels becoming reflexed; fruit a bluish-black, roughened berry. May–September. On dry, sandy soil.

119. CAPRIFOLIACEÆ. HONEYSUCKLE FAMILY.

Trees, shrubs, woody vines or herbs; leaves opposite, simple or pinnately compound, exstipulate, deciduous or evergreen; flowers perfect, regular or irregular, mostly in terminal cymes; calyx tube adherent to the ovary, 3–5-lobed; corolla rotate to tubular or urn-shaped, 3–5-lobed, sometimes bilabiate; stamens inserted in the tube of the corolla and alternate with its lobes; ovary 2–5-celled, ovules 1 in each cell, style slender, capitate or 2–5-lobed; fruit a 1–6-celled capsule, drupe or berry.

I. SAMBUCUS.

Shrubs; leaves pinnately compound; flowers white, regular, in large, terminal cymes; calyx tube ovoid, minutely 3–5-toothed or truncate; corolla rotate, 3–5-lobed; stamens 5, inserted in the base of the corolla; ovary 3–5-celled, style short, 3-parted; fruit berry-like, mostly 3-celled.

S. CANADENSIS L. ELDER. A branching shrub 6–10 ft. high; stem weak, pith very large; leaves odd-pinnate; leaflets 7–11, ovate to oval, acuminate at the apex, rounded at the base, short-stalked, serrate, smooth or slightly pubescent; cymes broad, flat-topped, 5-rayed; flowers small; fruit purplish-black. May–July. Common on low ground and along fences.

II. VIBURNUM.

Shrubs or small trees; leaves simple, entire, dentate or lobed, stipulate or exstipulate; flowers small, white, in terminal cymes, the outer flowers of the cyme sometimes greatly enlarged and sterile; calyx tube very small, 5-toothed; corolla rotate or campanulate, 5-lobed; stamens 5, inserted in the tube of the corolla; ovary 1–3-celled, 1–3-ovuled but only 1 ovule maturing, style short, 3-lobed; fruit a 1-seeded drupe.

1. V. acerifolium L. Maple-leaved Arrow-wood. A slender shrub 3–6 ft. high; leaves broadly ovate to cordate, palmately veined and 3-lobed, serrate or nearly entire, petioled, pubescent, becoming smooth above; cymes peduncled, about 7-rayed, 2–3 in. wide; sterile flowers none; fruit oval, black, stone flat, 2-ridged on the edges. May–June. In dry, open woods.

2. V. dentatum L. Arrow-wood. A shrub 8–15 ft. high; leaves broadly ovate to oval, acute at the apex, rounded or cordate at the base, coarsely dentate, smooth above, hairy in the axils of the veins beneath, short-petioled; cymes long-peduncled, 7-rayed, 2–3 in. wide; sterile flowers none; calyx smooth; fruit globose, dark blue, stone compressed, grooved on one side. March–May. In rich, damp soil.

3. V. nudum L. Withe-rod. A shrub 8–12 ft. high; leaves ovate to lanceolate, entire or slightly toothed, acute at both ends, thick, smooth above, the veins prominent beneath; petiole short; cymes short-peduncled, 5-rayed; sterile flowers none; fruit ovoid, blue. April–May. Common in swamps.

4. V. scabrellum T. & G. Rough Arrow-wood. A shrub 8–12 ft. high; leaves ovate to nearly orbicular, acute at the apex, cordate, rounded or cuneate at the base, coarsely serrate, thick, stellate-tomentose beneath, short-petioled; cymes peduncled, 7-rayed; calyx and corolla hairy; fruit globose, dark blue. May–June. Swamps and river banks.

5. V. prunifolium L. Black Haw. A small tree 15–20 ft. high; leaves oval to ovate, acute or obtuse at each end, finely and sharply serrate, smooth and shining above, often slightly pubescent beneath; petioles dilated and rusty-pubescent; cymes sessile, large, 4–5-rayed; sterile flowers none; drupe oval, bluish-black, edible. April–May. In rich, moist woods.

III. SYMPHORICARPOS.

Shrubs; leaves short-petioled, deciduous; flowers in axillary clusters; calyx tube globose, 4–5-toothed; corolla campanulate, 4–5-lobed, sometimes gibbous at the base, smooth or hairy within; stamens 4–5; ovary 4-celled, 2 of the cells with a single fertile ovule in each, the other cells with several abortive ovules; style slender, stigma capitate or 2-lobed; fruit a 4-celled, 2-seeded berry.

S. Symphoricarpos (L.) MacM. Coral Berry. A slender, branching shrub 2–4 ft. high; twigs purple; leaves oval to ovate, entire or nearly so, smooth above, pubescent beneath; flowers in small, axillary clusters; corolla pinkish, nearly smooth within; style bearded; fruit red, globose, persistent through the winter. June–September. River banks, on dry soil.

IV. LONICERA.

Shrubs or woody vines; leaves simple, usually entire, often connate; calyx tube ovoid, 5-toothed; corolla tubular to campanulate, often gibbous at the base or bilabiate; stamens 5; ovary 2–3-celled, ovules several in each cell, style slender, stigma capitate; fruit a 1–3-celled, 1–few-seeded berry.

1. L. flava Sims. Yellow Honeysuckle. Stem somewhat twining; leaves oval to obovate, obtuse, entire, green above, glaucous beneath, the lower short-petioled, the upper sessile or connate; flowers in crowded, terminal whorls, bright yellow, fragrant; corolla tube slender, 1–1½ in. long, bilabiate, 4-lobed, pubescent within; stamens and style exserted. April–July. On river banks and hillsides; often cultivated.

2. L. sempervirens L. Coral Honeysuckle. Stem twining high; leaves evergreen, oval to oblong, obtuse, entire, smooth above, pale and often pubescent beneath, the lower petioled, the upper pair nearly semi-orbicular and connate; flowering spikes terminal, bearing several whorls; corolla about 2 in. long, slender, smooth, the limb short, nearly equally 5-lobed, scarlet without, bright yellow within; stamens slightly exserted; fruit red. April–September. On low ground; often cultivated.

3. L. Japonica Thunb. Japan Honeysuckle. Stem twining high; young branches pubescent; leaves ovate to oblong, entire, smooth above, pale and pubescent beneath, all short-petioled; pedun-

cles axillary, 2-bracted, 2-flowered; flowers white or pink, fading to yellow, bilabiate, the lips nearly as long as the pubescent tube; stamens and style exserted; fruit black. May–August. Introduced from Japan; common in cultivation.

V. DIERVILLA.

Shrubs; leaves serrate, short-petioled; flowers in axillary cymes; calyx tube oblong, 5-toothed, teeth linear; corolla funnel-form, gibbous at the base, nearly equally 5-lobed; stamens 5; ovary 2-celled, many-ovuled, style slender, stigma capitate; fruit a 2-celled, 2-valved, many-seeded capsule.

D. JAPONICA Thunb. WEIGELA. A stout, branching shrub 3–6 ft. high; leaves broadly oval, acute at the apex, rounded at the base, coarsely serrate, rough above, pubescent beneath, short-petioled; flowers spreading, funnel-form, rose-color, 1–1½ in. long; calyx lobes deciduous; corolla pubescent without, the lobes spreading; capsule oblong or fusiform; seeds reticulate-winged. April–May. Introduced from Japan; common in cultivation.

120. VALERIANACEÆ. VALERIAN FAMILY.

Annual or perennial herbs; leaves opposite, exstipulate; flowers perfect or polygamo-diœcious, in panicled or corymbose cymes; calyx tube adherent to the ovary, the limb toothed, lobed, pappus-like or wanting; corolla tubular to funnel-form, 5-lobed, gibbous at the base; stamens mostly 3, inserted in the tube of the corolla; ovary 3-celled, 2 of the cells abortive, the other containing a single ovule; style filiform, stigma entire or lobed; fruit a nerved achene.

VALERIANELLA.

Annual herbs; stem forking regularly; leaves opposite, entire or dentate; flowers in crowded, terminal, bracted cymes; calyx limb toothed or wanting; corolla white or purplish, funnel-form, 5-lobed; stamens 3; style 3-lobed; fruit 3-celled, 1-seeded.

1. V. LOCUSTA (L.) Bettke. LAMB LETTUCE. Stem erect, smooth, or pubescent at the nodes, many times forked, 9–12 in.

high; basal leaves tufted, spatulate to obovate, entire, the upper lanceolate, dentate, sessile; cymes short-peduncled, bracts linear; flowers pale blue; fruit compressed, oblique. April–June. On rich soil in waste places.

2. V. RADIATA (L.) Dufr. CORN SALAD. Stem erect, smooth above, pubescent below, 2–4 times forked, 8–12 in. high; lower leaves spatulate, entire, the upper lanceolate, clasping at the base, dentate; cymes compact; bracts lanceolate; flowers white; fruit ovoid, downy, furrowed. February–April. On damp soil.

121. CUCURBITACEÆ. GOURD FAMILY.

Annual or perennial herbs; stems succulent, tendril-bearing, climbing or trailing; leaves alternate, simple, petioled, palmately veined or lobed, exstipulate; flowers axillary, solitary or racemed, monœcious or diœcious; calyx tube adnate to the ovary, 5-lobed; corolla usually gamopetalous, inserted on the calyx; stamens mostly 3, 2 of them with the anthers 2-celled, the other with the anther 1-celled; filaments short, often united; ovary 1–3-celled, style entire or lobed; fruit usually fleshy, 1–3-celled, seeds flat.

I. CUCURBITA.

Annual or perennial herbs; stem trailing, 2–20 ft. long; leaves angular-lobed; tendrils branching; flowers monœcious, solitary or in small clusters; calyx 5-toothed, the limb deciduous; corolla bell-shaped, 5-lobed; staminate flowers with 3 stamens and no pistil, pistillate flowers with 1 pistil and 3 abortive stamens; style short, stigmas 3–5, each 2-lobed; fruit 1-celled with numerous seeds on the 3 parietal placentæ.

1. C. MELOPEPO L. SUMMER SQUASH. Stem rough-hairy, angled, 2–5 ft. long; leaves broadly cordate, angularly 3–5-lobed, rough; flowers yellow, short-peduncled; fruit orbicular, longitudinally compressed, the margin smooth, wavy or tubercular. May–July. Common in cultivation.

2. C. VERRUCOSA L. CROOKNECK SQUASH. Stem rough-hairy, angled and striate, 5–10 ft. long; leaves cordate, deeply 5-lobed, very rough, long-petioled; flowers light yellow, long-peduncled; fruit clavate, the base often slender and curved, smooth or tuberculate, very variable. June–August. Common in cultivation.

II. MELOTHRIA.

Perennial; stem slender; tendrils rarely branched; leaves entire or angular-lobed; flowers polygamous or diœcious; staminate flowers clustered, calyx and corolla campanulate, 5-lobed, pistil minute or wanting; pistillate flowers solitary, calyx contracted above the ovary, corolla campanulate, 5-parted; ovary 3-celled, many-ovuled, style short, stigmas 3; fruit smooth, berry-like, many-seeded.

M. PENDULA L. CREEPING CUCUMBER. Stem very slender, smooth, branched, climbing, 3–6 ft. long; leaves cordate, rough, 3–5-lobed, the lobes toothed; flowers yellow, the staminate in few-flowered racemes, the pistillate solitary, on long and slender drooping peduncles; fruit oval, about $\frac{1}{2}$ in. long, greenish-black. May–August. In thickets on light soil.

III. SICYOS.

Annual; stem slender; tendrils branched; leaves angled; flowers monœcious; calyx tube campanulate, with 5 minute teeth; corolla rotate, the limb deeply 5-parted; staminate flowers in racemes, pistillate flowers in capitate clusters; ovary 1-celled, 1-ovuled, style short, slender, stigmas 3; fruit membranaceous, bristly, 1-seeded.

S. ANGULATUS L. STAR CUCUMBER. Stem slender, clammy-pubescent, somewhat angled, climbing 10–20 ft.; tendrils mostly 3-forked; leaves thin, cordate to orbicular, angled and denticulate, rough on both sides; flowers greenish-white; fruit long-peduncled, yellowish, indehiscent. June–August. River banks and damp places.

[Among the cultivated plants belonging to this family are the watermelon and citron (*Citrullus vulgaris*), the cucumber (*Cucumis sativus*), the muskmelon (*Cucumis melo*), and the Gourd (*Lagenaria vulgare*).]

122. CAMPANULACEÆ. BELL-FLOWER FAMILY.

Annual, biennial or perennial herbs, juice acrid or milky; leaves alternate, entire, dentate or lobed, exstipulate; flowers perfect, regular or irregular; calyx tube adherent to the

ovary, the limb 3–5-lobed, usually persistent; corolla inserted at the top of the calyx tube, 5-lobed, often bilabiate with the tube split to the base on one side; stamens 5, alternate with the lobes of the corolla, filaments and anthers distinct or united; ovary 1–5-celled, style single, smooth or bearded; fruit a capsule.

I. CAMPANULA.

Annual, biennial or perennial herbs; flowers solitary, racemed or spiked, regular, blue or white; calyx 5-lobed or parted; corolla rotate to bell-shaped, 5-lobed; stamens 5, free from the corolla, distinct, filaments dilated at the base; ovary 3–5-celled, many-ovuled, style 3-parted; capsule short, bearing the persistent calyx lobes at its apex, many-seeded, dehiscent on the sides.

C. Americana L. Tall Bell-flower. Annual or biennial; stem erect, slender, smooth or pubescent, simple or with a few ascending branches above, 2–5 ft. high; leaves ovate to lanceolate, acuminate at the apex, tapering below into a short petiole, serrate, thin; flowers in an elongated, leafy spike, single or 2–3 together; calyx lobes slender, spreading; corolla blue, 1 in. wide, rotate; style curved, long-exserted; capsule strongly ribbed, longer than the calyx lobes. June–September. In moist, open woods.

II. LEGOUZIA.

Annual; stems slender, angled; leaves entire or toothed; flowers axillary, regular, solitary or in small clusters, sessile, bracted; calyx tube slender, 3–5-parted; corolla rotate, 5-lobed; stamens with the filaments flattened and shorter than the anthers; ovary 3-celled, many-ovuled, stigmas 3; fruit a prismatic, 3-celled, many-seeded capsule.

1. L. biflora (R. & P.) Britt. Specularia. Stem erect, simple or branched from the base, angles roughened, 10–20 in. high; leaves ovate to lanceolate, acute at the apex, sessile, crenate or entire, the upper bract-like; flowers solitary or in pairs; corolla blue, often wanting; capsule cylindrical, smaller above. March–July. In waste places.

2. L. PERFOLIATA (L.) Britt. VENUS'S LOOKING-GLASS. Stem simple or branched, slightly pubescent, smooth or rough on the angles, 1–2 ft. high; leaves very numerous, round-cordate, clasping at the base, crenate or sometimes entire; flowers solitary or 2–3 together; calyx teeth 3–5; corolla blue, sometimes wanting; capsule oblong, ribbed. May–September. Common in fields and waste places.

III. LOBELIA.

Annual, biennial or perennial, with acrid, poisonous juice; stems erect; leaves alternate, sometimes nearly all basal, mostly serrate with glandular-pointed teeth; flowers in terminal, leafy-bracted spikes or racemes, red, white or blue, irregular; calyx 5-lobed; tube of the corolla straight or curved, split to the base on one side, the limb bilabiate, the upper lip smaller, with 2 erect or reflexed lobes, the lower lip spreading, 3-lobed; stamens 5, free from the corolla, monadelphous, some or all of the anthers with a tuft of hair at the apex, united around the style; ovary 2-celled, many-ovuled, style single, slender, stigma 2-lobed, fringed; fruit a 2-celled, many-seeded capsule.

1. L. PALUDOSA Nutt. SWAMP LOBELIA. Perennial; stem smooth and glabrous, simple or with a few erect branches, nearly leafless, 2–4 ft. high; leaves mostly basal, fleshy, spatulate to linear, entire or denticulate, the lower narrowed into a petiole, the upper sessile; flowers small, pale blue or white, in loose racemes, bracts small; calyx lobes slender, not appendaged; lower lip of the corolla pubescent. May–August. Swamps in pine barrens.

2. L. CARDINALIS L. CARDINAL FLOWER. Perennial; stem stout, smooth or slightly pubescent, simple, 2–4 ft. high; leaves numerous, oblong to lanceolate, acuminate at the apex, denticulate, thin, smooth or slightly pubescent, the lower petioled, the upper sessile; flowers in a bracted raceme, bright scarlet, 1–1½ in. long, very showy; bracts leaf-like; calyx smooth or pubescent, not appendaged, the lobes linear; stamens and style exserted. June–September. On wet soil.

3. L. SYPHILITICA L. BLUE LOBELIA. Perennial; stem stout, pubescent, simple, 1–3 ft. high; leaves very numerous, lanceolate to oval, acute at each end, thin, smooth, coarsely serrate, sessile or the lower petioled; flowers bright blue, in a dense, leafy raceme; calyx hairy, the lobes lanceolate, denticulate, half the length of the corolla, with deflexed, auricled appendages in the sinuses; corolla about 1 in. long, glabrous. June–October. On wet soil.

4. L. SPICATA Lam. SPIKED LOBELIA. Biennial or perennial; stem pubescent, simple, 1–3 ft. high; lower leaves oval to obovate, obtuse at the apex, denticulate, narrowed below to the short petiole, upper leaves smaller, lanceolate, sessile; raceme long and dense; pedicels short; bracts linear; flowers small, pale blue; calyx tube smooth, shorter than the lobes, without appendages; corolla $\frac{1}{3}$–$\frac{1}{2}$ in. long. June–August. On dry, sandy soil.

123. CICHORIACEÆ. CHICORY FAMILY.

Annual or perennial herbs; juice milky, usually acrid and bitter; leaves alternate or basal; flowers in a close head which is surrounded by an involucre consisting of 1 or more rows of bracts; the receptacle naked or with chaffy scales, nearly smooth or pitted, flat or convex; flowers perfect; the calyx tube adnate to the ovary, the limb sometimes wanting, but usually prolonged above into a pappus of scales, bristles, or fine hairs which are often plumose; corolla tubular below, prolonged above into a strap-shaped or ligulate ray which is usually 5-toothed at the apex; stamens 5, inserted in the tube of the corolla, the anthers united into a ring about the slender, 2-lobed style; ovary 1-celled; fruit an achene.

I. SERINIA.

Annual; stem branching, glaucous; leaves lanceolate to linear, entire or lobed, petioled or sessile; flowers yellow, in long-peduncled heads; the involucre spreading in flower, connivent in fruit, usually of 8 equal bracts about as long as the corollas; receptacle naked; achenia ovoid-oblong, ribbed and striate, pappus none.

S. OPPOSITIFOLIA (Raf.) Kuntze. SERINIA. Stem very glaucous, succulent, branched below, 4–12 in. high; lower leaves lanceolate, entire or pinnatifid, long-petioled, the upper narrower and usually entire, clasping, the two highest often nearly opposite; peduncles long and slender, often glandular-pubescent near the apex; heads 10–20-flowered; rays truncate, 5-toothed at the apex. March–May. In dry, open fields.

II. ADOPOGON.

Annual or perennial; leaves mostly basal, entire, toothed or pinnatifid; heads long-peduncled, 15–many-flowered; involucre of 6–15 nearly equal bracts in 1 or 2 rows; receptacle naked; flowers yellow or orange; rays truncate, 5-toothed at the apex; achenes short, oblong or top-shaped, 4–5-angled and ribbed; pappus double, the outer row of short, chaffy scales, the inner of slender bristles.

1. A. Virginicum (L.) Kuntze. Goat's-beard. Perennial; stem erect, smooth and glaucous, branched above, 1–2 ft. high; leaves oval to oblong, the lower long-petioled and toothed, the upper sessile and often entire; stem umbellately branched, bearing 2–5 long-peduncled heads; involucral bracts 9–15; flowers orange; achenes oblong, 15–20-ribbed; scales of the pappus oblong, numerous, bristles slender, numerous. April–July. Common on sandy soil.

2. A. Dandelion (L.) Kuntze. Goat's-beard. Perennial; acaulescent; roots often bearing small tubers; leaves spatulate-oblong to linear, entire or toothed; scapes often several, leafless, glaucous, 6–15 in. high; heads single; involucral bracts 12–15; flowers yellow; achenes somewhat top-shaped, obscurely 4-angled; pappus of numerous short scales and slender bristles. March–May. Common on damp soil.

3. A. Carolinianum (Walt.) Britt. Carolina Goat's-beard. Annual; nearly acaulescent; leaves spatulate-oblong, mostly lyrate or pinnatifid, glaucous or slightly pubescent; scapes several, glaucous, 3–12 in. high; involucral bracts 6–15, in 2 irregular rows, reflexed at maturity; flowers yellow; achenes top-shaped, 5-angled; pappus of 5 short and rounded scales and 5–10 rough bristles. February–May. On dry, sandy soil.

III. TARAXACUM.

Perennial; acaulescent; leaves all basal, entire or pinnatifid; scapes often several, tubular; heads large, solitary; involucre double, the outer several irregular series of unequal, spreading bracts, the inner a single row of equal, erect bracts which are somewhat united at the base, all reflexed at maturity; receptacle naked; flowers yellow; rays truncate, 5-toothed at the apex; achenes oblong, with 5–10 roughened nerves, tapering into a slender beak above; pappus of numerous white hairs.

T. TARAXACUM (L.) Karst. DANDELION. From a large, deep root; leaves spatulate to elliptical, irregularly toothed or pinnatifid, narrowed into a margined petiole; scapes erect, 4–12 in. high; heads $1\frac{1}{2}$–2 in. wide; involucral bracts lanceolate to linear; flowers bright yellow, very numerous; achenes quite rough above, $\frac{1}{4}$–$\frac{1}{3}$ the length of the filiform beak which is developed as the achenes mature; pappus a globose tuft of soft, white hairs. February–July. In lawns and along roadsides; introduced.

IV. SONCHUS.

Annual or perennial; leaves mostly toothed or pinnatifid, prickly margined; heads in corymbs or panicles; bracts in several series, the outer shorter; receptacle naked; flowers yellow; rays truncate, 5-toothed at the apex; achenes oval to oblong, compressed, ribbed, truncate at the apex; pappus of numerous soft, white hairs.

1. S. OLERACEUS L. SOW THISTLE. Annual; stem erect, branched, smooth, 2–6 ft. high; leaves spiny toothed, the lower long-petioled, very irregularly cut or pinnatifid, the upper clasping by an auricled base; involucre downy when young; achenes striate and transversely wrinkled. May–August. In waste places on very rich soil.

2. S. ASPER (L.) All. SPINY SOW THISTLE. Annual; stem erect, smooth, branched but little, 2–6 ft. high; leaves undivided, spatulate to oblanceolate, fringed with spiny teeth, the lower narrowed into a petiole, the upper clasping by an auricled base, the auricles rounded; heads numerous; involucre glabrous; achenes flattened, margined, 3-nerved on each side, smooth. May–September. In waste places.

V. LACTUCA.

Annual, biennial or perennial; stems leafy; leaves entire to pinnatifid; heads panicled; involucre cylindrical, bracts unequal, imbricated in 2 or more rows, the outer shorter; receptacle naked; flowers blue, yellow or white; rays truncate, 5-toothed at the apex; achenes compressed, ribbed, the apex contracted into a slender beak which is enlarged into a disk bearing the soft, hairy, white or tawny pappus.

1. L. CANADENSIS L. WILD LETTUCE. Biennial; stem erect, smooth, hollow, branched above, 3–10 ft. high; leaves lanceolate to

spatulate, pale beneath, the lower petioled and pinnatifid, the upper sessile, clasping, and nearly entire; heads numerous, about 20-flowered; flowers yellow; achenes oval, flat, 1-ribbed on each side, minutely roughened, about as long as the beak; pappus white. June–October. In waste places.

2. L. VILLOSA Jacq. BLUE LETTUCE. Stem very leafy, smooth, paniculately branched above, 3–6 ft. high; leaves ovate to lanceolate, acuminate, often hairy beneath, the lower on winged petioles and often sinuate-lobed, the upper sessile; heads racemed, on divergent and bracted peduncles; flowers blue; achenes slightly compressed, beak very short; pappus white. June–September. In waste places.

VI. SITILIAS.

Annual or biennial; stem erect, leafy below, nearly naked above, smooth; leaves oblong, toothed or pinnatifid; heads large, long-peduncled; involucre cylindrical or spreading, the inner row of bracts erect, united at the base, the outer rows shorter and spreading; receptacle naked; flowers yellow; rays truncate, 5-toothed at the apex; achenes oblong, 5-ribbed, narrowed above into a long and slender beak; pappus soft, tawny, with a short, villous ring at the base.

S. CAROLINIANA (Walt.) Raf. FALSE DANDELION. Annual or biennial; stem glabrous, furrowed, branched above, 2–3 ft. high; lower leaves lanceolate to oblong, entire, toothed or pinnatifid, narrowed into a margined petiole, the upper sessile, bract-like, entire; heads few, long-peduncled, peduncles and involucre sometimes puberulent; inner bracts calloused at the apex, the outer subulate and spreading; achenes much shorter than the filiform beak. April–July. Common in fields.

124. COMPOSITÆ. THISTLE FAMILY.

Herbs or shrubs, with watery or resinous juice; leaves opposite, alternate or basal, entire, toothed, or divided, exstipulate; flowers in heads surrounded by an involucre of bracts in 1 or more rows; the receptacle naked or chaffy, smooth or pitted, concave, flat or convex; flowers perfect or variously imperfect; calyx tube adnate to the ovary, the limb prolonged above into a pappus of scales, bristles or

hairs, or rarely wanting; corolla tubular, 5-toothed or rarely bilabiate, the corollas of the marginal flowers often prolonged into a strap-shaped or ligulate ray; when both tubular and ray flowers are present the head is said to be radiate, and when all the flowers are tubular it is said to be discoid; stamens usually 5, united by their anthers into a ring about the slender, 2-cleft style; fruit an achene.

The largest family of flowering plants, and the one in which the flowers are most highly specialized. Fully ten thousand species are known, though comparatively few are of great economic importance. Most of the species bloom late in the season.

Heads discoid.
  Receptacle naked.
    Pappus of chaffy bristles . . . I. Elephantopus.
    Pappus of capillary bristles . . . II. Eupatorium.
    Pappus of plumose bristles . . . III. Lacinaria.
    Pappus of bearded bristles . . . IV. Trilisa.
  Receptacle chaffy . . . . . XII. Bidens.
  Receptacle bristly . . . . . XVI. Carduus.

Heads radiate.
  Rays yellow.
    Receptacle naked.
      Pappus capillary, heads racemed . . V. Solidago.
      Pappus capillary, heads corymbed . XV. Senecio.
      Pappus of chaffy scales . . . XIII. Helenium.
    Receptacle chaffy.
      Leaves alternate, rays fertile . . VIII. Silphium.
      Leaves alternate, rays neutral . . IX. Rudbeckia.
      Leaves opposite.
        Pappus of 2 chaffy scales or wanting.
          Involucre in several rows . . X. Helianthus.
          Involucre in 2 rows . . . XI. Coreopsis.
        Pappus of 2–4 barbed awns . . XII. Bidens.

Rays white or purplish.
  Receptacle naked.
    Disk flowers tubular.
      Bracts imbricated in several rows . VI. Aster.
      Bracts only slightly imbricated . VII. Erigeron.
    Disk flowers bilabiate . . . XVII. Thyrsanthema.
  Receptacle chaffy . . . . . XIV. Achillea.

I. ELEPHANTOPUS.

Perennial herbs; stem scape-like, corymbosely branched above; leaves mostly basal and nearly entire; heads small, in dense, bracted clusters, discoid, 3–5-flowered; involucre oblong, its bracts about 8, in 2 series, the outer shorter; receptacle naked; corollas all alike, deeply 5-lobed, deeply cleft on one side, purple; achenes oblong, ribbed, hairy; pappus of rigid, awn-like scales or bristles which are dilated at the base.

1. E. Carolinianus Willd. Carolina Elephant's Foot. Stem erect, hairy, leafy, 1–2 ft. high; leaves oval to obovate, obtuse at the apex, narrowed below into a winged petiole, serrate or dentate, the upper often sessile; bracts 3–5, ovate, longer than the heads; involucral bracts slightly hairy; achenes hairy, 10-ribbed. June–September. In damp, shady places.

2. E. tomentosus L. Woolly Elephant's Foot. Stem erect, rough-hairy, nearly leafless, 1–2 ft. high; leaves mostly basal, obovate-oblong, on a margined petiole, crenate, soft-pubescent beneath, stem leaves 1 or 2, small, sessile; bracts ovate to cordate, shorter than the heads, involucral bracts very hairy; achenes nearly smooth, 10-ribbed. June–August. In damp soil.

II. EUPATORIUM.

Perennial herbs; stems leafy; leaves opposite, verticillate or sometimes alternate, often resinous-dotted; heads discoid, 3-many-flowered, in cymes or panicles; involucre cylindrical or spreading, its bracts imbricated in 2 or more series; receptacle naked; flowers white, blue or purple; corolla slender; achenes 5-angled, truncate, smooth; pappus a single row of rough bristles.

1. E. PURPUREUM L. PURPLE BONESET. Stem erect, smooth or slightly pubescent, often striate, branched above, 3–10 ft. high; leaves 3–6 in a whorl, lanceolate to ovate, petioled, coarsely serrate, roughened; heads in large, compound corymbs, 5–10-flowered; bracts purplish, obtuse, imbricated in several rows, the outer shorter; flowers pink or purple. July–September. In moist woods.

2. E. ALBUM L. WHITE THOROUGHWORT. Stem erect, rough-pubescent or hairy, branched above, 1–3 ft. high; leaves opposite, lanceolate to oblong, obtuse or acute at the apex, narrowed at the base, nearly or quite sessile, serrate, strongly veined; heads numerous, in dense corymbs, 5-flowered; involucre slender, its bracts in 2–3 series, linear to lanceolate, with white and scarious edges, the tips mucronate; flowers white. July–September. Common on dry, sandy soil.

3. E. ROTUNDIFOLIUM L. ROUND-LEAVED THOROUGHWORT. Stem erect, rough-pubescent, simple or branched above, 2–3 ft. high; leaves opposite, broadly ovate to roundish, truncate and sessile at the base, obtusely serrate, 3-ribbed, rugose; corymbs large, heads 5-flowered; involucre spreading, its bracts in 2–3 series, lanceolate, densely pubescent; flowers white. June–September. On dry soil.

4. E. PERFOLIATUM L. BONESET. Stem erect, stout, pubescent or hairy, branched above, 2–4 ft. high; leaves opposite, lanceolate, connate-perfoliate, crenate-serrate, rugose, with a prominent vein near the margin; corymb large and spreading; heads about 10-flowered; involucre spreading, the bracts linear-lanceolate, acute; flowers white. July–September. On low ground. A popular domestic remedy.

5. E. CŒLESTINUM L. MIST FLOWER. Stem erect, slender, smooth or pubescent, widely branched, 2–3 ft. high; leaves opposite, ovate to deltoid or sometimes cordate, acuminate at the apex, petioled, coarsely dentate; corymbs spreading, heads many-flowered; involucre spreading, bracts nearly equal, linear-lanceolate; flowers blue or purple. June–September. On rich soil.

III. LACINARIA.

Perennial from tuberous roots; stems usually simple; leaves alternate, narrow, entire; heads discoid, spiked or racemed, few- or many-flowered; involucre oblong or bell-shaped, its bracts imbricated in several rows, the outer shorter; receptacle naked; corollas slender, purple to white; achenes slender, narrowed to the base, 10-ribbed; pappus of numerous plumose bristles.

1. L. SQUARROSA (L.) Hill. BLAZING-STAR. Stem erect, stout, simple, smooth or pubescent, 1–2 ft. high; leaves numerous, linear,

rigid, smooth or hairy, 3–5-ribbed; heads few, about 1 in. long, in a leafy-bracted spike, many-flowered; bracts in several rows, with rigid, acuminate, spreading tips; lobes of the corolla hairy; pappus very plumose. June–September. On dry soil.

2. L. ELEGANS (Walt.) Kuntze. SHOWY BLAZING-STAR. Stem erect, tomentose, simple, 2–3 ft. high; leaves very numerous, linear, punctate, the upper small and bract-like; heads very numerous, showy, 4–5-flowered, in a long and dense spike or raceme; bracts numerous, in 2–3 series, the tips of the inner ones spreading and petal-like, the outer ones loose; pappus very plumose. July–August. On dry pine barrens.

3. L. SCARIOSA (L.) Hill. BUTTON SNAKEROOT. Stem stout, simple, pubescent, 3–6 ft. high; leaves pubescent and punctate, the lower spatulate to oblanceolate, the upper linear and acute; heads large, often 1 in. wide, many-flowered, sessile or short-peduncled, in long spikes; flowers bluish purple; involucral bracts in several series, obtuse, the margins colored; pappus short-plumose. July–September. On dry soil.

4. L. SPICATA (L.) Kuntze. SPIKED BUTTON SNAKEROOT. Stem erect, smooth, simple, very leafy, 3–6 ft. high; lower leaves linear, obtuse, erect, 1 ft. or more in length, 3–5-ribbed, the upper smaller and bract-like; heads in a long and dense spike, cylindrical, 8–12-flowered; flowers blue-purple to white; involucral bracts in 4–6 rows, smooth, purple, obtuse and scarious-margined at the apex; pappus short-plumose. July–September. On moist soil.

IV. TRILISA.

Perennial from a fibrous root; leaves alternate; heads in corymbs or panicles, few-flowered, discoid; bracts in 2–3 rows, the outer shorter; receptacle naked; corolla 5-lobed; achenes oblong, 10-ribbed; pappus of barbed bristles.

T. ODORATISSIMA (Walt.) Cass. DEER-TONGUE. VANILLA PLANT. Stem erect, stout, smooth and glaucous, often purple, branched above, 2–4 ft. high; lower leaves oblong to spatulate, 3–5-ribbed, thick, smooth, entire, petioled, the upper smaller and sessile; heads in corymbs, 7–9-flowered, flowers purple; bracts oblong, obtuse; achenes pubescent; pappus minutely bearded. July–September. In flat pine barrens. The withering plants strongly vanilla-scented.

V. SOLIDAGO.

Perennial herbs, or rarely shrubby; leaves alternate, entire or toothed; heads small, radiate; involucral bracts imbri-

cated in several rows; receptacle pitted; flowers yellow, ray flowers 1–16, in a single row, pistillate, disk flowers mostly perfect; achenes terete, ribbed; pappus of numerous, slender, scabrous bristles. A large genus, nearly all flowering late in the season.

1. S. CÆSIA L. BLUE-STEMMED GOLDEN-ROD. Stem erect, slender, smooth and glaucous, usually blue or purple, simple or branched, 2–3 ft. high; leaves lanceolate, acuminate, sessile, sharply serrate, smooth; heads in axillary racemes shorter than the leaves, about 10-flowered; rays 3–4; achenes pubescent. August–September. In woods and thickets.

2. S. CANADENSIS L. CANADIAN GOLDEN-ROD. Stem stout, erect, rough-pubescent, branched above, 3–8 ft. high; leaves lanceolate, serrate, 3-nerved, the lower petioled, the upper sessile; heads very numerous, on one side of the curved branches of a large panicle; involucral bracts linear; ray flowers 9–15; achenes pubescent. July–November. Margins of fields, on dry ground.

3. S. NEMORALIS Ait. FIELD GOLDEN-ROD. Stem slender, erect, gray with dense pubescence, simple, 1–2 ft. high; leaves obscurely 3-nerved, the lower lanceolate to spatulate, serrate, petioled, the upper lanceolate, mostly entire, sessile; heads many, the racemes in a dense panicle with curved branches, 10-12-flowered; bracts linear-oblong; ray flowers 6–7; achenes pubescent. June–August. Common in open fields.

VI. ASTER.

Perennial or rarely annual; leaves alternate; heads usually corymbed or panicled, many-flowered, radiate; bracts imbricated in several rows, the outer shorter, the tips spreading; receptacle naked, pitted; ray flowers pistillate, in a single row, disk flowers perfect, tubular; achenes compressed, nerved; pappus a single or double row of slender, scabrous bristles.

1. A. AZUREUS Lindl. BLUE ASTER. Stem erect, slender, rigid, rough, branched above, 2–3 ft. high; lower leaves lanceolate to cordate, acute or obtuse at the apex, truncate or cordate at the base, entire, long-petioled, the upper lanceolate to linear, sessile, those of the branches subulate; heads numerous; involucre turbinate, the bracts smooth, appressed; ray flowers 10–20, bright blue; pappus tawny. July–September. On dry ground.

2. A. UNDULATUS L. WAVY-LEAVED ASTER. Stem erect, rigid, rough-pubescent, widely branched above, 2–3 ft. high; leaves lanceolate to ovate, rough, entire, undulate or serrate, the lower cordate,

on long and margined petioles which are clasping at the base, the upper sessile or clasping, those of the branches very small; heads numerous, racemose, $\frac{3}{4}$ in. wide; involucral bracts linear; ray flowers 8–15, pale blue; pappus white. July–October. Common on dry soil, and very variable.

3. A. PATENS Ait. PURPLE ASTER. Stem erect, rough-pubescent, widely branched above, 2–4 ft. high; leaves ovate-oblong to lanceolate, thin, acute or obtuse, clasping by an auricled base, the upper small and bract-like, with ciliate margins; heads numerous, 1 in. wide, on the ends of the paniculate branches; bracts linear; ray flowers 20–30, blue or violet; pappus tawny; achenes pubescent. July–October. Common on dry ground.

4. A. CONCOLOR L. SILVERY ASTER. Root often tuberous; stem erect, slender, smooth or pubescent above, simple, 2–3 ft. high; leaves lanceolate to oblong, entire, sessile, silky on both sides when young; heads numerous, terminating the peduncle-like branches, the bracts lanceolate, appressed, with spreading tips; ray flowers 10–15, lilac; achenes silky; pappus tawny. July–October. On dry, sandy ground.

5. A. DUMOSUS L. BUSHY ASTER. Stem erect, slender, smooth, much branched, 2–3 ft. high; lower leaves spatulate, dentate, the upper nearly linear and entire, those of the branches subulate; heads very numerous, small, campanulate; bracts linear, with spreading tips; ray flowers 15–30, purple or white; achenes pubescent, pappus white. July–October. Common and quite variable.

VII. ERIGERON.

Annual or perennial; leaves alternate; heads solitary, panicled or corymbed, hemispherical, many-flowered, radiate; bracts nearly equal, in 1 or 2 rows; receptacle naked; ray flowers numerous, pistillate, white to purple, disk flowers tubular, perfect; achenes compressed, 2-nerved; pappus a row of slender, scabrous bristles, often with an outer row of chaffy scales or short bristles.

1. E. PHILADELPHICUS L. FLEABANE. Perennial, often producing runners; stem erect, slender, hairy, branched above, 2–4 ft. high; leaves thin, entire or coarsely toothed, sessile, the lower spatulate-oblong, the upper lanceolate, clasping; heads in corymbs or panicles, peduncled; bracts linear; ray flowers numerous, shorter than the bracts, narrow, purplish; achenes slightly pubescent; pappus a single row of bristles. April–July. Common on low ground.

2. E. RAMOSUS (Walt.) B. S. P. DAISY FLEABANE. Annual;

stem erect, slender, rough-pubescent, paniculately branched above, 2–3 ft. high; leaves entire or slightly serrate, pubescent, the lower oval to oblong, long-petioled, the upper lanceolate to linear, sessile; heads small, in corymbose panicles; bracts smooth; ray flowers numerous, white or purplish; pappus double, the outer row of short, chaffy scales, the inner of rough hairs. May–September. Common in old fields.

3. E. VERNUS (L.) T. & G. EARLY FLEABANE. Perennial, from a thick rootstock; stem erect, slender, smooth, scape-like, 1–2 ft. high; leaves mostly basal, spatulate to obovate, thick, entire or slightly toothed, with a margined petiole, upper leaves small and bract-like; heads in small, peduncled corymbs; bracts linear; ray flowers 20–30, white or pink; pappus single. March–May. Common on wet ground.

VIII. SILPHIUM.

Perennial herbs with resinous juice; stems erect, leafy; leaves alternate, opposite or whorled; heads radiate, large, in corymbs or panicles; involucral bracts leafy, imbricated in several rows, the inner small and chaffy; receptacle with linear, acute chaff; ray flowers numerous, yellow, pistillate and fertile, disk flowers numerous, perfect but sterile; style undivided; achenes in 3–4 rows, compressed, orbicular to obovate, winged on the edges, emarginate at the apex; pappus none, or coalesced with the 2 teeth of the achene.

1. S. LACINIATUM L. COMPASS PLANT. Stem stout, striate, rough-hispid with white hairs, very resinous, few-leaved, simple, 4–8 ft. high; leaves mostly basal, petioled, oval in outline, deeply pinnately parted, rough-hispid, mostly erect and facing to the east or west, stem leaves alternate, small, nearly entire; heads spiked or racemed; bracts large, ovate, the tips spreading; ray flowers 20–30, 2–3 in. wide; achenes round-obovate, emarginate. June–September. On prairies and open grounds.

2. S. TEREBINTHINACEUM Jacq. PRAIRIE DOCK. Stem smooth, branched above, nearly leafless, 3–8 ft. high; leaves nearly all basal, cordate-ovate, acute at the apex, coarsely toothed, rough, long-petioled, mostly facing to the east or west; heads loosely panicled, 2–3 in. wide; bracts oval, obtuse, smooth; ray flowers 12–20; achenes obovate, 2-toothed at the apex. June–September. In open woods and fields.

IX. RUDBECKIA.

Perennial or biennial; leaves alternate, entire or lobed; heads radiate, long-peduncled, many-flowered; bracts imbricated in 2–3 series, spreading; receptacle convex or long-conical, with concave, chaffy scales; ray flowers yellow, neutral, disk flowers purple to brown, perfect; achenes smooth, 4-angled, truncate; pappus a few short teeth or wanting.

1. R. TRILOBA L. THIN-LEAVED CONE-FLOWER. Biennial; stem erect, rough-hairy, branched, 2–5 ft. high; leaves thin, rough on both sides, the lower long-petioled, simple or with 2 lateral lobes, middle leaves short-petioled, deeply 3-lobed or parted, the lobes serrate, upper leaves mostly simple, sessile, entire; heads numerous, 1–1½ in. wide; bracts narrowly lanceolate, pubescent; ray flowers 8–10, disk flowers purplish-black; scales awned, smooth, as long as the flowers; pappus a few minute scales. June–September. On open ground.

2. R. HIRTA L. CONE-FLOWER. Usually biennial; stem erect, rough-hairy, simple or branched, 2–3 ft. high; leaves lanceolate to oblong, thick, obscurely serrate, hispid, 3-ribbed, the lower petioled, the upper sessile; heads few, long-peduncled; bracts hispid, spreading; ray flowers 10–20, orange-yellow, disk flowers purplish-brown; chaff acute, hairy at the apex; pappus none. May–August. On dry, open ground.

3. R. LACINIATA L. TALL CONE-FLOWER. Perennial; stem smooth, branched, 3–10 ft. high; leaves thin, pubescent or roughened, the lower pinnately divided, the lobes irregularly cut and lobed, middle leaves 3–5-lobed or divided, the upper leaves often entire; heads few or many; bracts nearly equal; ray flowers 6–10, yellow, 1–1½ in. long, disk flowers yellowish; chaff truncate, pubescent at the apex, about as long as the achenes; pappus of very short scales. June–September. In damp woods.

X. HELIANTHUS.

Annual or perennial herbs; leaves opposite or alternate, undivided, usually 3-ribbed; heads radiate, few or many, solitary or corymbed; bracts in several series, the tips spreading or appressed; receptacle chaffy; ray flowers neutral, disk flowers perfect, tubular; achenes oblong to obovate, compressed, 4-angled; pappus of 2–4 deciduous awns or scales.

1. H. ANNUUS L. SUNFLOWER. Annual; stem erect, striate, hispid, branched above, 6–12 ft. high; leaves ovate to deltoid, 3-nerved, dentate, petioled, rough above, rough-pubescent beneath; heads terminating the branches, 4–10 in. wide; ray flowers numerous, yellow; disk flowers purple; chaff 3-cleft; achenes obovate, smooth or slightly pubescent. June–September. Native of the northwestern states; common in gardens.

2. H. DIVARICATUS L. WOODLAND SUNFLOWER. Perennial, from a slender rootstock; stem slender, smooth, branched above, 2–5 ft. high; leaves opposite, ovate-lanceolate, acuminate at the apex, rounded at the base, serrate, very rough above, smooth or pubescent beneath; heads few, 1–3 in. wide, on short peduncles; bracts lanceolate to linear, spreading, as long as the disk; ray flowers 8–12, light yellow, disk flowers yellow; chaff entire or 3-toothed, pubescent at the apex; achenes obovate, smooth; pappus of 2 awns. July–September. Common in woods.

3. H. DECAPETALUS L. WILD SUNFLOWER. Perennial, from a thickened rootstock; stem erect, slender, pubescent above, smooth below, branched, 2–5 ft. high; leaves ovate to ovate-lanceolate, thin, rough above, 3-nerved, acuminate at the apex, rounded at the base, coarsely serrate, short-petioled, the lower opposite, the upper alternate; heads many, yellow, 2–3 in. wide; bracts lanceolate-linear, spreading, the outer longer than the disk; ray flowers 8–12; chaff 3-toothed or entire, pubescent at the apex; achenes smooth; pappus of 2 slender awns. July–September. Common on damp soil.

XI. COREOPSIS.

Annual or perennial herbs; leaves opposite or the upper alternate, entire or pinnately divided; heads radiate, solitary or corymbed, many-flowered; bracts in 2 rows of about 8 each, the inner membranaceous and appressed, the outer narrower and spreading; receptacle chaffy; ray flowers neutral, disk flowers tubular, perfect; achenes compressed, oval to oblong, often winged; pappus of 2 scales or bristles, or wanting.

1. C. TINCTORIA Nutt. GARDEN COREOPSIS. Annual; stem erect, smooth, branched, 2–3 ft. high; leaves 2–3 times pinnately divided, the divisions linear, lower leaves petioled, the upper often sessile and entire; heads 1–1½ in. wide, on slender peduncles; inner bracts brown with scarious margins, outer bracts very short; ray flowers about 8, yellow with a brown base, 3-lobed at the apex; achenes linear; pappus minute or none. April–September. Common in gardens.

2. C. LANCEOLATA L. TICKSEED. Perennial; stem slender, erect or ascending, smooth or slightly pubescent below, simple, 9–15 in. high; leaves opposite, the lower spatulate to elliptical, sometimes lobed, on long, ciliate petioles, the upper lanceolate, sessile; heads few, on long peduncles; bracts ovate-lanceolate, the outer narrower; ray flowers 6–10, rays 3–5-lobed, bright yellow; achenes oval, broadly winged, warty; pappus of 2 teeth. May–June. On rich, dry soil.

3. C. AURICULATA L. RUNNING TICKSEED. Perennial; stem ascending or decumbent, weak, smooth, nearly simple, 6–15 in. long; leaves ovate to oval, entire or with 2–4 small and rounded lobes at the base, pubescent, long-petioled; heads 1–1½ in. wide, few or single; outer bracts narrower than the inner; rays 6–10, mostly 4-toothed at the apex; chaff as long as the flowers; achenes oblong, the wings narrow and thickened; pappus of 2 minute teeth. April–May. In rich woods.

XII. BIDENS.

Annual or perennial; leaves opposite, simple or pinnately divided; heads radiate or discoid, corymbed; bracts in 2 series, the outer often long and leaf-like; receptacle chaffy; ray flowers neutral or wanting, disk flowers perfect; achenes flat or 4-angled; pappus of 2–4 downwardly barbed bristles.

1. B. FRONDOSA L. BEGGAR TICKS. Annual; stem erect, smooth or slightly pubescent, usually purple, branched, 2–5 ft. high; leaves pinnately 3–5-divided, the segments lanceolate to oval, acuminate, sharply serrate, thin; heads discoid, long-peduncled; outer bracts leaf-like; achenes flat, narrowly wedge-shaped, ciliate on the edges; pappus of 2 awns. June–September. A common weed.

2. B. BIPINNATA L. SPANISH NEEDLES. Annual; stem erect, slender, smooth, 4-angled, branched, 2–5 ft. high; leaves bipinnate, the segments small, ovate to lanceolate, acute, serrate; heads small, radiate; bracts narrow, nearly equal; ray flowers 2–4, yellow, short; achenes linear, 4-angled, slightly pubescent; pappus of 4 barbed awns. July–September. A common weed.

XIII. HELENIUM.

Annual or perennial; leaves alternate, decurrent on the stem; heads radiate, peduncled, many-flowered; bracts in 2 series, the outer linear and spreading, the inner few and scale-like; receptacle naked, convex or oblong; ray flowers

pistillate and fertile, or neutral, the rays cuneate, 3–5-lobed, disk flowers perfect, tubular, 4–5-lobed; achenes top-shaped, hairy, ribbed; pappus of 4–5 entire, toothed or awned scales.

1. H. NUDIFLORUM Nutt. SNEEZEWEED. Perennial; stem slender, erect, pubescent, branched above, 1–2 ft. high; leaves lanceolate, entire or slightly toothed, the lower petioled, the upper sessile; heads numerous, ray flowers 10–15, neutral, yellow or yellow and brown, disk flowers purple; achenes hairy on the ribs; pappus of ovate, denticulate, awned scales. May–June. Common on river banks.

2. H. TENUIFOLIUM Nutt. BITTERWEED. Annual; stem erect, widely branched, smooth, 1–2 ft. high; leaves very numerous, filiform, sessile; heads on long and slender peduncles; bracts subulate, soon reflexed; ray flowers 4–8, fertile, the rays drooping; pappus of ovate, entire, awned scales. June–October. A troublesome roadside and pasture weed.

XIV. ACHILLEA.

Perennial; leaves alternate, pinnately divided; heads radiate in a terminal corymb; involucral bracts imbricated in several series, the outer shorter; receptacle chaffy; ray flowers white or pink, pistillate and fertile, disk flowers perfect, tubular, 5-lobed; achenes oblong, compressed, slightly margined; pappus none.

A. MILLEFOLIUM L. YARROW. Stems often clustered, erect from a creeping rootstock, simple, pubescent or tomentose, 1–2 ft. high; leaves lanceolate or oblong, the segments finely cut and divided, smooth or pubescent, the lower petioled, the upper sessile; heads small, numerous, in flat-topped corymbs; bracts pubescent; ray flowers 4–5, white or pink, rays 3-lobed at the apex. May–September. Common in old fields.

XV. SENECIO.

Annual or perennial; stems often hollow; leaves alternate, entire or pinnately divided; heads radiate or discoid, in terminal corymbs; bracts mostly in a single row, often with a few shorter ones at the base: receptacle naked or pitted; ray flowers yellow or orange, pistillate and fertile when present, disk flowers tubular, perfect; achenes terete or compressed,

not beaked or winged, 5–10-ribbed, pubescent; pappus of numerous, slender, white hairs.

1. S. TOMENTOSUS Michx. WOOLLY RAGWEED. Perennial; woolly throughout; stem stout, erect, mostly simple, 2–3 ft. high; lower leaves ovate to oblong, crenate or entire, obtuse, long-petioled, stem leaves few, elliptical to oblanceolate, serrate or toothed, acute, sessile; heads radiate, $\frac{3}{4}$ in. wide, on slender peduncles; bracts narrow, becoming smooth; ray flowers 12–15, yellow; achenes hairy. April–June. On damp soil.

2. S. AUREUS L. GOLDEN RAGWEED. Perennial; stems often tufted, erect, slender, woolly when young, branched above, 18–30 in. high; lower leaves broadly ovate, obtuse at the apex, cordate at the base, crenate, long-petioled; stem leaves lanceolate and often pinnatifid, the upper small and sessile; heads radiate, corymbed, on slender peduncles; ray flowers 8–12, bright yellow; achenes smooth. May–July. On wet soil; very variable.

3. S. LOBATUS Pers. BUTTERWEED. Annual; stem erect, ridged, hollow, often woolly when young, and becoming smooth with age, branched above, 1–3 ft. high; leaves lyrate-pinnatifid, thin, the lower petioled, the upper sessile; heads radiate in a terminal corymb; bracts linear, acute; ray flowers about 12, yellow; achenes slightly hispid on the angles; pappus scabrous, longer than the involucre. March–May. Common on low ground.

XVI. CARDUUS.

Biennial or perennial; stem erect, simple or branched; leaves alternate, prickly, often decurrent; heads discoid, terminal and solitary or corymbed, many-flowered; bracts imbricated in many series, the outer shorter, usually spine-pointed; receptacle bristly; corollas purplish or nearly white, the tube slender, deeply 5-cleft; achenes oblong, 4-angled, smooth or ribbed; pappus of numerous simple or plumose bristles.

1. C. ALTISSIMUS L. TALL THISTLE. Perennial or biennial; stem stout, very leafy, pubescent or tomentose, branched, 4–10 ft. high; leaves rough-pubescent above, hoary beneath, fringed with fine prickles, not decurrent, the lower petioled and often pinnatifid, the upper sessile and entire; heads ovoid, 1 in. in diameter; bracts viscid, webby when young, all except the inner ones tipped with weak and spreading bristles; flowers light purple. July–September. Common in fields and waste places.

2. C. SPINOSISSIMUS Walt. YELLOW THISTLE. Biennial or perennial; stem erect, stout, woolly when young, becoming smooth, often purple, branched, 1–3 ft. high; leaves pinnatifid, with very spiny teeth, mostly sessile and clasping, smooth and green on both sides; heads large, surrounded by a whorl of linear-oblong, pectinate leaves; involucral bracts linear, ciliate, not spine-tipped; flowers purple or yellowish. April–June. On sandy soil.

XVII. THYRSANTHEMA.

Perennial, acaulescent herbs; leaves green above, white-tomentose beneath; scapes single or few, each bearing a single head of white or purplish flowers; heads radiate, many-flowered; bracts imbricated in several rows, appressed, the outer shorter; receptacle naked; ray flowers in 2 rows, pistillate and fertile, the outer ligulate, entire or 3-toothed at the apex, the inner 3–5-toothed, filiform, disk flowers perfect but sterile, the corolla bilabiate, 5-toothed; styles entire; achenes oblong, 5-nerved; pappus of numerous white hairs.

T. SEMIFLOSCULARE (Walt.) Kuntze. SPRING DAISY. Leaves narrowly oval to spatulate, nearly prostrate, smooth above, densely white-woolly beneath, entire; scapes leafless, erect, slender, tomentose, 6–12 in. high; heads about 1 in. wide, nodding in the bud, becoming erect in flower; bracts lanceolate to linear; rays broadly linear, pinkish-purple; achenes narrowed at each end, smooth; pappus of numerous bristle-like hairs. February–April. Very common on low ground.

GLOSSARY OF TERMS USED IN DESCRIPTIONS.

Abortive. Rudimentary or imperfect.
Abruptly pinnate. With two terminal leaflets.
Acaulescent. The stem not rising above the surface of the ground.
Appressed. Pressed closely to the main body.
Aril. An additional, usually fleshy, growth surrounding the seed.
Aristate. Awned.
Auriculate. Furnished with rounded, ear-like lobes.
Baccate. Fleshy or berry-like.
Bipinnate. Bipinnatifid. Twice pinnate, or twice pinnatifid.
Biternate. Twice ternate, or twice three-parted.
Caducous. Dropping off as soon as fully grown.
Campanulate. Bell-shaped.
Canescent. Hoary or grayish white.
Caruncle. An excrescence at the scar of some seeds.
Ciliate. With hairs on the margins.
Circinate. Rolled inward from the top.
Coma. A tuft of hairs.
Connate. Grown together.
Connivent. Converging, drawn together.
Coriaceous. Leathery or chaffy in texture.
Cuneate. Wedge-shaped.
Declined. Turned to one side.
Decurrent. Continued downward along the stem.
Depressed. Flattened from the apex.
Didynamous. In two pairs of unequal length.
Distinct. Wholly separate from each other.
Dorsal. Pertaining to the back.
Equal. Of the same size and shape.

Exfoliate. Peeling off in plates.
Exserted. Protruding beyond the surrounding envelop.
Fimbriate. Fringed.
Fusiform. Spindle-shaped.
Gibbous. Swelled on one side.
Glabrous. Smooth.
Glaucous. Covered with bloom, as a cabbage leaf.
Hirsute. Hairy with long, straight hairs.
Hispid. Bristly with stiff hairs.
Hoary. See *Canescent.*
Inflated. Swollen and bladder-like.
Lenticular. Nearly flat, but somewhat convex on both sides.
Nodulose. Knobbed.
Odd-pinnate. With a single, terminal leaflet.
Puberulent. Very minutely downy.
Pubescent. Hairy with short, fine, and soft hairs.
Punctate. Minutely dotted.
Reticulated With a network of veins.
Rosulate. Flat, roselike.
Rugose. Roughened with wrinkles.
Saprophytic. Living on dead vegetable matter.
Scabrous. Rough.
Scape. A peduncle arising from the surface of the ground.
Scarious. Thin and papery.
Sessile. Not stalked.
Setaceous. Bristle-like.
Sinus. The space between two lobes.
Stipe. The stalk of a pistil or ovary.
Subulate. Awl-shaped.
Terete. Cylindrical.
Tomentose. Clothed with woolly hairs.
Torulose. Twisted.
Villous. Clothed with long and soft hairs.

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